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# DAVIDSON
# LABORATORY

**THE PERFORMANCE OF A SMALL**

**14 TON TRACKED AMPHIBIAN IN**

**CALM AND ROUGH WATER**

by

**G. FRIDSMA AND W.E. KLOSINSKI**

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Calm and rough water tests were performed on a 1/6 scale model of a small 14 ton amphibious tracked vehicle. The program was carried out over a range of speeds to 12 mph at two load conditions with variations in the wheel-track suspension and bow flap configurations. In addition to describing the model, apparatus and test procedures, the report presents and analyzes the data. A discussion of the results includes a performance comparison with the large 26 ton amphibian, the LVTP-7.

# STEVENS INSTITUTE OF TECHNOLOGY
## DAVIDSON LABORATORY
### Castle Point Station, Hoboken, New Jersey 07030

Technical Report 2250

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THE PERFORMANCE OF A SMALL 14 TON
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G. Fridsma and W.E. Klosinski

Prepared for

David W. Taylor

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Code 112

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P. Ward Brown, Manager
Marine Craft Development Group

## TABLE OF CONTENTS

## INTRODUCTION

Hydrodynamic performance tests on a 1/6 scale model of a small tracked amphibian were carried out as part of a general program being conducted in support of the Marine Corps Surface Mobility Exploration Development Plan. Under the direction of the David W. Taylor Naval Ship Research and Development Center (NSRDC), Code 112, which manages the Mobility Program, the Davidson Laboratory has been carrying out a series of investigations into the hydrodynamic characteristics of amphibious vehicles. This investigation is concerned with tank tests of a 14 ton tracked amphibian model, denoted as "FLASH", in calm water and head seas.

Amphibious craft of the 14 ton size must operate in essentially the same sea environment as larger 26 ton vehicles. With its inherently lower freeboard, the small craft may develop serious hydrodynamic problems such as bow immersion, which could significantly affect its behavior in calm water and waves. It is essential therefore that model tests be undertaken to identify potential problem areas, to seek solutions, and to define the hydrodynamic characteristics of these small amphibians. Changes in the hull geometry, such as track suspension position and bow planes, were explored over a range of speed to determine powering requirements and any tendency for bow immersion in both calm water and waves. Motions, accelerations, and deck wetness in the seaway were also obtained.

The tests outlined above were carried out in the Davidson Laboratory Tank No. 3 facility during the period 7 to 14 December 1981, and were witnessed in part by Mr. Walter Zeitfuss, Jr., Code 112. Along with a description of the model, test apparatus, and experimental procedures, this report also tabulates all the data, analyzes and discusses the results and makes recommendations on how to improve its hydrodynamic performance.

## MODEL

A 1/6 scale model of the FLASH amphibian was fabricated at the Davidson Laboratory according to drawings supplied by Code 112, NSRDC.

Figures 1 and 2 give a general picture of the model. In full scale values, the small amphibian has a design weight of 28,000 lb, an overall length (not including the bow flap) of 16.75 ft, an overall width of 8.83 ft, and a depth from the ground plane to the deck of 6.17 ft. It includes the water jet cavity, a retractable wheel-track suspension system, and a variable geometry bow flap.

The hull was constructed of 3/4 inch marine plywood covered with a layer of epoxy impregnated fiberglass. Catalyzed urethane hull and deck enamel was used to further seal the hull. The track wheels were made by cutting sections of plastic PVC pipe and cementing thin plastic blanks inside one end. The five ground wheels on each side were mounted on a 1/4 inch thick aluminum, horizontal bar. Retracting the wheels was a matter of remounting this bar higher up in the hull, so that the tracks were level with the hull bottom. Each track was made from a standard ribbed timing belt, which was cut to size and rejoined with small springs, which tensioned the belt. The track springs kept the tracks tight without any sag in both the extended and retracted positions. Wheel covers were made of styrofoam cylinders, which fit flush inside each wheel. These were made for tests with the wheels covered and served the purpose of streamlining the wheels as well as providing extra buoyancy.

The basic bow flap was made in two pieces; a flat plate piece, which was mounted parallel to the bottom portion of the bow, and a removable deadrise section, which was hinged to the first plate. This arrangement allowed for variations in the height and slope of the bow flap, with or without deadrise. The sketch on Page 3 describes the features of the bow flap.

The flat portion of the bow flap consisted of an aluminum plate equipped with two inside rails, which rode in channels imbedded in the
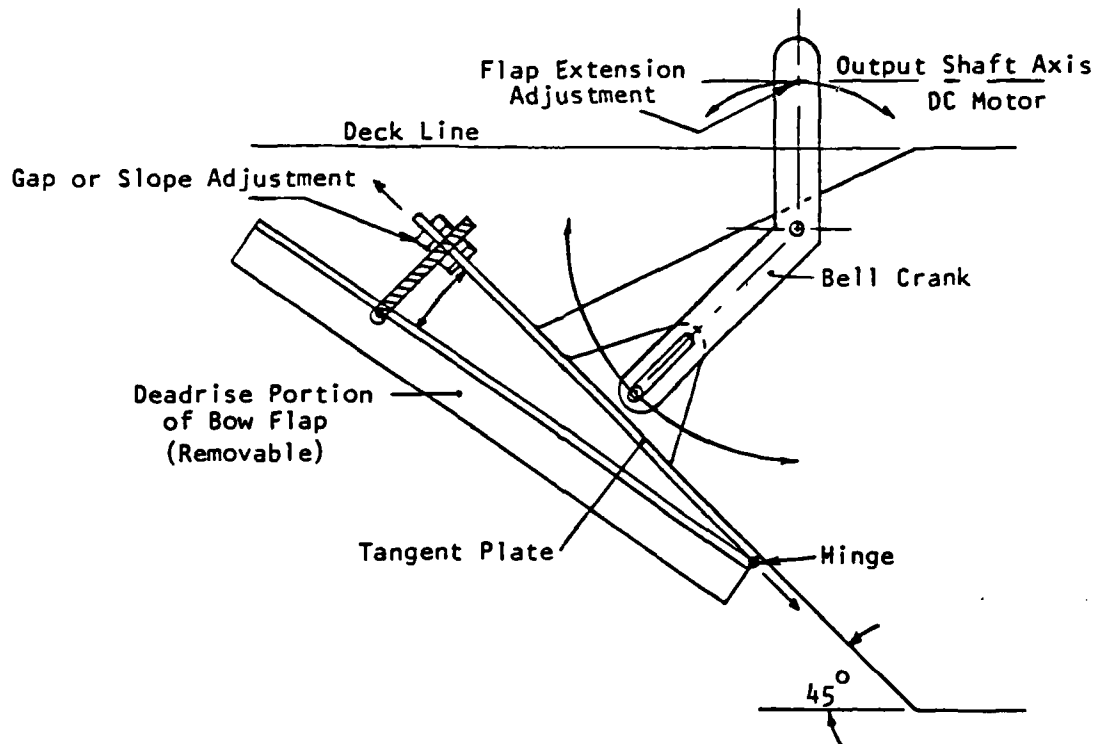
bow. Moving parallel to the 45 degree sloping bottom portion of the bow, the plate had a maximum travel of 2.30 ft full size, starting with the plate's leading edge being flush with the top sloping portion of the bow. The actual extension of this plate was accomplished through a powered remote control, which provided for fine adjustments of the flap before and during the test run.

The deadrise portion of the flap consisted of another flat plate hinged to the bottom of the first so called "tangent" plate. A 6 degree deadrise section was sandwiched to the hinged plate and extended 1 ft above the leading edge of the tangent plate. An adjustment was provided at the upper end of the hinged plate to control the gap between the two plates. With the exception of Run 79, all flap positions (with or without deadrise and with or without gap) were set with the leading edge

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level with the hull deck, so that the flap would not obstruct the driver's forward vision. The adjustments for the bow flap extension and angle were included for test purposes only and are not a feature of the proposed prototype vehicle.

The model was fitted with a watertight lucite deck and is shown under test on Figure 3.


## APPARATUS AND INSTRUMENTATION

### Model Instrumentation

An inclinometer was mounted in the model for measuring the trim in calm water. It was further used to calibrate and reference the zero on the pitch transducer for wave tests. Also included in the model were two accelerometers, one located at the driver's station and the other at the pitch axis.

### Facility Instrumentation

The Davidson Laboratory Tank No. 3 was used for conducting tests on the 1/6 scale "FLASH" model. A standard free-to-heave apparatus was coupled to the model through a drag balance and pitch pivot box. While the model was free-to-pitch and heave, it was restrained in yaw, roll, sway, and surge. The pitch axis was located 2.20 ft above the hull bottom and 8.69 ft aft of the bow, full size. The vertical displacement of the pitch axis and the angular rotation of the model about the pitch axis were measured and recorded. A wave strut ahead and to port of the model was used to monitor wave encounters and wave profile during the irregular wave runs.

The transducer signals were relayed by overhead cables to the data station on shore where they were filtered (40 Hz low pass) and processed by an on-line PDP-8e computer, which includes an analog-to-digital converter. Rough water time histories were recorded on analog magnetic tape. All tests were monitored on a direct writing oscillograph.

## Wavemaker

The Tank No. 3 plunger type wavemaker, located at the far end of the tank, was used to generate irregular waves simulating a Sea State 2 (significant height = 2.2 ft). The waves consist of a quasi-random reproducible set of 100 waves having a variance density distribution approximating the Pierson-Moskowitz spectra. The experimental spectrum was measured prior to testing and is shown on Figure 4.

## Photography

A color video camera was mounted on a camera carriage ahead of and to port of the model. Video recordings were made of all data runs and were monitored on a shore based TV receiver. Above water color photographs were taken of selected runs.

## DATA REDUCTION

Calibrations of the instrumentation were made by applying known loads to the force balance, gravity multiples to the accelerometers, and known displacements to the motion and wave elevation transducers. During calibration, the outputs from the transducers were sent to the PDP-8e computer. All calibrations were linear, and straight lines were fitted to these data by the least squares technique.

Data channels were scanned by the PDP-8e computer at the rate of 250 Hz and stored in the computer for processing. Test results were determined from the differences between transducer outputs in the running and known static reference conditions. Velocities were computed from the time taken to travel through the data zone, which was 50 ft for calm water tests, and 150 ft for wave tests.

Processing of the calm water data resulted in the mean values for the drag, draft, and trim. For the wave tests, a peak-trough analysis was carried out on the pitch and heave motions, and the pitch axis and driver accelerations. The peak-trough analysis computes or lists for

each signal the mean and rms, the number of oscillations and buffer size, the average of the peaks and troughs, the average of the 1/3 highest and the 1/10 highest peaks and troughs, and the extreme values of the peaks and troughs. Buffers were used to suppress small oscillations associated with noise rather than the substantive time histories.

## TEST PROGRAM

The object of the test program for evaluating "FLASH" was three-fold. First of all, the bow flap had to be optimized in terms of effectiveness coupled with least drag and best spray behavior. Secondly, the hydrodynamic characteristics as a function of load and track configuration had to be determined. Finally the motions and loads in irregular waves (Sea State 2) together with the added resistance were to be obtained.

The model was ballasted to two loading conditions. These full size quantities were:

| Load, lb | VCG, in. Above Ground Plane | LCG, in. Aft of Bow |
|---|---|---|
| 25,600 | 42.4 | 104.3 |
| 28,000 | 42.4 | 107.9 |

Extension of the bow flap altered the CG position slightly but not more than one percent from the above values.

The parameters tested were selected from the following matrix:

| | |
|---|---|
| Speeds | 0 to 12 mph |
| Tracks and suspension | extended or retracted |
| Wheel covers | on or off |
| Bow flap (even with deck line, see sketch Page 7) | a) flat or 6 degree deadrise |
| | b) 45 degree or 35 degree slope (closed gap or open gap) |

The extended position of the tracks corresponds to the ground plane; retracted position is with the tracks flush with the hull bottom. When the deadrise portion of the bow flap was removed, it was replaced by an equivalent weight.

Deck Line

4.18

5.18

1.75

Closed Gap
Flat Plate Flap

10°

35°

Open Gap
Flat Plate Flap

2.85

45°

Closed Gap
6° Deadrise Flap

Deck Line

10°

Open Gap
6° Deadrise Flap
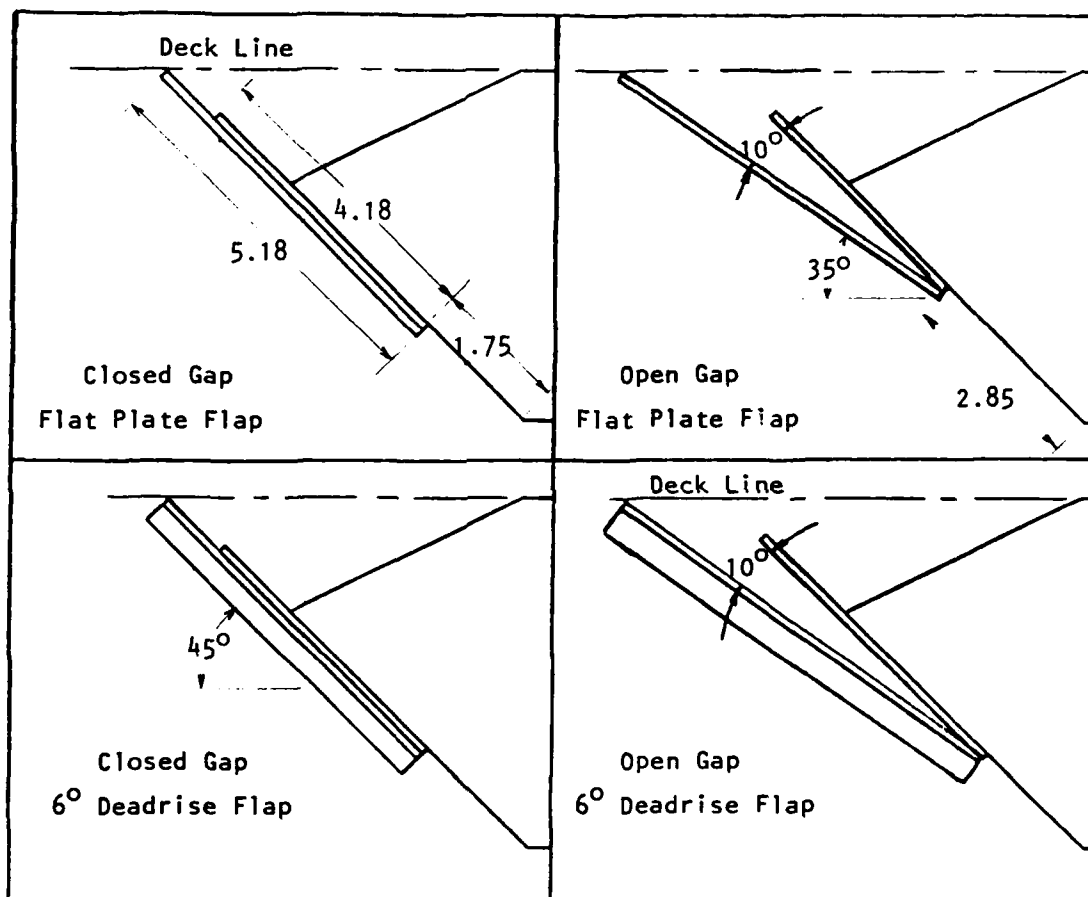
BOW FLAP CONFIGURATIONS (Dimensions in Full Scale Feet)
Open Gap is With Flap 35 Degrees Relative to Baseline

As a result of the calm water testing, optimum bow flap and track configurations were identified, namely incorporating deadrise and a 35 degree slope on the flap and running with the tracks retracted and with wheel covers on. This produced the least drag and deck wetness.

The rough water test program consisted of model tests with the optimum bow flap configuration and the wheel covers on. The two loading conditions with the tracks extended and retracted were run over the same range of speeds to obtain their effect in waves. As a result of a bow submergence problem, some special runs were made. These will be discussed later.

## RESULTS

The results of the test are presented in Tables 1 through 7; numbers 1 and 2 being the calm water data and 3 through 7 the rough water data. A description follows.

| TABLE | CALM/ROUGH WATER | LOAD lb | TRACK POSITION | WHEEL COVERS | BOW FLAP |
|-------|------------------|---------|----------------|--------------|----------|
| 1.1 | Calm | 25,600 | Extended | off | As Noted |
| 1.2 | Calm | 25,600 | Retracted | off/on | As Noted |
| 2.1 | Calm | 28,000 | Extended | off | As Noted |
| 2.2 | Calm | 28,000 | Retracted | off/on | As Noted |
| 3 | Sea State 2 | 25,600 | Extended | on | With Deadrise and Gap |
| 4 | Sea State 2 | 25,600 | Retracted | on | With Deadrise and Gap |
| 5 | Sea State 2 | 25,600 | Retracted | on | Maximum Up With Deadrise and Gap |
| 6 | Sea State 2 | 28,000 | Extended | on | With Deadrise and Gap |
| 7 | Sea State 2 | 28,000 | Retracted | on | With Deadrise and Gap |

In calm water, the results are tabulated by load in short tons (s-tons) which is the full scale displacement, speed (mph), the draft (ft) or submergence of the hull bottom at the pitch axis, trim (deg) or angle of the baseline relative to the horizontal, positive bow up, drag (lb) and drag/load, drag non-dimensionalized by load in lb per short ton.

In rough water (Tables 3 through 7) each page presents data for
one run and includes the peak-trough statistics associated with each
data channel. The page numbers for each table (denoted by the decimal
.1, .2, .3 etc.) are arranged in order of increasing speed. Statistics
are included for the pitch and heave motions, where heave is defined
as the height of the pitch axis above the calm water surface, and the
two accelerations for the driver position and pitch axis position.
The latter acceleration is denoted in the table as the CG acceleration.
The statistics for each data channel are the mean and rms values, and
the average, average of the 1/3 highest (significant), average of the
1/10 highest, and extreme for both the peaks and troughs. The mean
value for speed and drag in lb per short ton are also included.

A video tape recording of all runs has been forwarded to Code 112,
NSRDC. A scenario of this tape is included in Table 8.

## DISCUSSION

Testing of the small 14 ton tracked amphibian gave a clear
impression that the craft performed well in calm water. There was
always a positive increase of trim with speed, indicating that the
vehicle with bow flap was developing lift forward, despite the low
freeboard and the negative floating trims of some of the 12.8 ton
conditions with its forward LCG position. At 6 mph the bow wave comes
up to the leading edge of the flap; at 8 to 10 mph a small amount of
water comes over the bow flap, but the area in back of the flap is
still generally clear of water; at 12 mph, the trim is sufficiently
high that the leading edge of the flap is well above the bow wave. In
all of these conditions (Runs 1 through 66) driver visibility as regards
deck wetness was excellent, and no bow immersion problem was evident.

The calm water drag characteristics of "FLASH" are shown on
Figures 5, 6 and 7 where the non-dimensionalized drag is plotted
against speed for various loads and bow flap configurations. On each
of the graphs, it is clear that the bow flap configurations and load

have little effect on the drag, despite the rather large changes in trim (see corresponding trim Figures 8, 9 and 10). Track retraction results in a 14 percent reduction in drag at 8 mph. An additional 5 percent reduction in drag is realized by fitting wheel covers.

The data for the LVTP-7, with the bow flap and tracks down, is used to put the performance of the 14 ton small amphibian in perspective. The LVTP-7 characteristics are indicated by solid lines on Figures 5 to 15. The LVTP-7 is a large 26 ton amphibian, 10 ft longer and 2 ft wider than FLASH. The LVTP-7 has less drag than the 14 ton vehicle on a non-dimensional basis, by about 25 percent at 8 mph (Figure 5) which shows the advantage of size. However, by retracting the tracks and adding wheel covers, the performance of FLASH can be made to approach that of the LVTP-7 (Figure 7).

The trim of the LVTP-7 is noticeably below that of FLASH, which contributes to the LVTP-7's bow burying problem (see Figures 8, 9 and 10).

The added resistance due to waves is indicated on Figures 11 and 12 for the tracks extended and tracks retracted position respectively. At 8 mph, an increase of 80 lb/ton is attributable to waves in Sea State 2, an increase of 30 percent (see Figure 12) over the calm water value. The LVTP-7 witn bow flap in Sea State 2 is also shown in Figure 12; the drag/ton is very similar to the "FLASH" performance in calm water.

The heave and pitch motions (Figures 13 and 14) are not seriously changed with track position. The light load does account for a small decrease in motions. Beyond 8 mph the motions decrease with speed. At 8 mph and lower speeds, significant double amplitude motions of 2 ft of heave and 16 degrees of trim can be expected. The LVTP-7 motions, also shown, indicate similar heave behavior, but a 5 degree reduction in the significant pitch motions.

The single amplitude accelerations are presented on Figure 15. As expected the driver accelerations are slightly higher than those

at the pitch axis. Maximum significant accelerations over the speed range from 8 to 12 mph can reach values of 0.2 g at the pitch axis (CG) and 0.25 g at the driver's station. The LVTP-7 results are compared with the FLASH pitch axis accelerations since the longitudinal positions of the accelerometers in both vehicles as a percentage of the length are more closely related. The LVTP-7 results are 0.03 to 0.05 g lower than those of the small amphibian.

At the design load of 14 tons, the configuration with the deadrise bow flap extended at 35 degrees operated successfully at either track position over the entire speed range in both calm water and waves. This was also true for the light load in the tracks down position. At the light load with tracks up, the model amphibian experienced some difficulty at 8 mph; it submerged its bow.

Raising the bow flap to 45 degrees (no gap) and to its fully extended position (Run 79, Table 5) solved the bow immersion problem but introduced the matter of driver visibility. Since it was thought that the tangent plate (which would not be present on the prototype) might be trapping water, the plate was removed and the configuration rerun at 8 mph. The same behavior with the bow submerging occurred.

In order to find out why the light load condition in waves ran well with tracks extended and yet submerged its bow when the tracks were retracted, additional calm water tests were conducted. It became obvious that at 8 mph, the tracks down configuration ran at 0.5 degrees higher running trim than with the tracks up, 3.8 vs. 3.2 degrees (Run 12 compared with Run 38, in Tables 1.1 and 1.2). The immersion problem is therefore a matter of the mean running trim and appears to be very sensitive to it at the light load. The higher running trims associated with the aft CG at the design load accounts for the satisfactory performance of this condition.

Additional trials were run in calm water (tracks retracted) to see if some combinations of parameters not previously tested would submerge the bow. Results indicated that if the bow flap was run at 35 degrees (with gap), the bow stayed up. When the bow flap was run at 45 degrees (without gap) then both the 12.8 and 14 ton loads with deadrise submerged their bows at 8 mph in calm water. Removing the

deadrise portion with the flap at 45 degrees, also caused the 12.8 ton load to submerge its bow, this time at the lower speed of 6 mph.

The configuration of the design load, with tracks up and wheel covers in place, operated successfully in both calm and rough water with the deadrise bow flap at 35 degrees. This configuration has the least drag and minimum deck wetness. For the light load forward CG condition, which immersed its bow at 8 mph, there are a number of options open to prevent this behavior. These could be used individually or in combination: lower the tracks; increase the bow flap extension and increase its slope; move the CG further aft; and finally, limit speed of this configuration to 7 mph.

## CONCLUDING REMARKS AND RECOMMENDATIONS

A small tracked amphibian (FLASH) was tested over a range of speeds, at two loading conditions, and with various track and bow flap configurations. In addition to describing the model, apparatus, and test techniques, the report presents and analyzes the data. A discussion of the results includes a performance comparison with the large 26 ton amphibian, the LVTP-7, in order to put the FLASH data in perspective.

The calm water performance shows the drag/ton increasing with speed particularly beyond 8 mph. Reductions in the calm water resistance can be realized by retracting the wheel-track suspension and streamlining the wheels with covers. At 8 mph, for example, retracting the tracks reduces the drag by 14 percent. Wheel covers reduce the drag by another 5 percent. Added resistance in waves (Sea State 2) however increases the calm water values by 30 percent at this speed. Bow flap configuration and load have an insignificant effect on the drag per short ton, despite rather large changes in the running trim.

Significant accelerations are below 0.3 g at the driver's station with reductions further aft along the hull. The average 1/3 highest (significant) double amplitude motions can be as high as 2 ft of heave at the CG and 16 degrees of pitch at, 8 mph.

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The design load condition (14 ton) with tracks up and with the deadrise bow sloped at 35 degrees should be the configuration to design to. It is the configuration with least drag/ton and deck wetness and operates successfully in both calm water and Sea State 2. The light load of 12.8 tons with its corresponding forward CG shift creates a bow immersion problem at 8 mph in Sea State 2. This behavior can be prevented by either lowering the tracks, extending the length or increasing the slope of the bow flap, shifting the CG further aft or limiting the speed to 7 mph.

Generally, the behavior of the 14 ton vehicle FLASH with its bow flap extended appears to be a successful design of a low-freeboard tracked amphibian.

## TABLE 1.1

### CALM WATER PERFORMANCE

Displacement  25,600 lb, LCG  104.3 inches
Tracks Extended, Various Bow Flap Configurations
Wheel Covers Off

| RUN | LOAD s-ton | SPEED mph | DRAFT ft | TRIM deg | DRAG lb | DRAG/LOAD lb/s-ton |
|-----|-----------|-----------|----------|----------|---------|--------------------|
| | | | Bow Flap with Deadrise, No Gap | | | |
| 7 | 12.8 | 0.00 | 3.56 | 0.00 | 0. | 0. |
| 2 | 12.8 | 2.00 | 3.60 | 0.13 | 180. | 14. |
| 3 | 12.8 | 4.00 | 3.69 | 0.45 | 730. | 57. |
| 4 | 12.8 | 6.00 | 3.85 | 1.08 | 1,830. | 143. |
| 5 | 12.8 | 8.00 | 4.12 | 1.92 | 3,890. | 304. |
| 9 | 12.8 | 8.00 | 4.13 | 1.34 | 3,970. | 310. |
| 6 | 12.8 | 10.00 | 4.30 | 6.20 | 7,670. | 599. |
| 8 | 12.8 | 12.00 | 4.17 | 13.64 | 14,840. | 1,160. |
| | | | Bow Flap with Deadrise, and Gap | | | |
| 10 | 12.8 | 0.00 | 3.51 | - 0.49 | 0. | 0. |
| 30 | 12.8 | 0.00 | 3.50 | - 0.31 | 0. | 0. |
| 11 | 12.8 | 6.00 | 3.85 | 1.42 | 1,900. | 148. |
| 12 | 12.8 | 8.00 | 4.04 | 3.84 | 3,830. | 299. |
| 13 | 12.8 | 10.00 | 4.19 | 7.69 | 7,870. | 615. |
| 14 | 12.8 | 10.34 | 4.12 | 8.64 | 8,710. | 681. |
| 15 | 12.8 | 12.00 | 4.00 | 13.57 | 14,320. | 1,119. |
| | | | Bow Flap without Deadrise, No Gap | | | |
| 28 | 12.8 | 0.00 | 3.56 | - 1.42 | 0. | 0. |
| 29 | 12.8 | 4.01 | 3.69 | - 0.77 | 830. | 65. |
| 31 | 12.8 | 6.00 | 3.82 | 0.31 | 1,920. | 150. |
| 32 | 12.8 | 8.00 | 4.04 | 2.14 | 3,940. | 308. |
| 33 | 12.8 | 10.00 | 4.36 | 5.64 | 7,970. | 623. |

## TABLE 1.2

### CALM WATER PERFORMANCE

Displacement  25,600 lb, LCG  104.3 inches

Tracks Retracted, Various Bow Flap Configurations

| RUN | LOAD s-ton | SPEED mph | DRAFT ft | TRIM deg | DRAG lb | DRAG/LOAD lb/s-ton |
|-----|-----------|-----------|----------|----------|---------|---------------------|
| | | | | | | |
| Bow Flap with Deadrise, and Gap, Wheel Covers Off | | | | | | |
| 34 | 12.8 | 0.00 | 3.63 | - 0.55 | 0. | 0. |
| 35 | 12.8 | 2.01 | 3.65 | - 0.34 | 180. | 14. |
| 36 | 12.8 | 4.01 | 3.73 | 0.24 | 680. | 53. |
| 37 | 12.8 | 5.99 | 3.88 | 1.09 | 1,650. | 129. |
| 38 | 12.8 | 8.00 | 4.08 | 3.17 | 3,310. | 258. |
| 39 | 12.8 | 10.00 | 4.22 | 7.15 | 6,310. | 493. |
| 40 | 12.8 | 12.00 | 4.21 | 12.77 | 12,420. | 971. |
| | | | | | | |
| Bow Flap without Deadrise, with Gap Wheel Covers Off | | | | | | |
| 53 | 12.8 | 0.00 | 3.67 | - 1.54 | 0. | 0. |
| 57 | 12.8 | 0.00 | 3.65 | - 1.55 | 0. | 0. |
| 58 | 12.8 | 0.00 | 3.66 | - 1.56 | 0. | 0. |
| 54 | 12.8 | 4.01 | 3.78 | - 0.49 | 750. | 58. |
| 55 | 12.8 | 6.00 | 3.90 | 0.47 | 1,780. | 139. |
| 56 | 12.8 | 8.00 | 4.12 | 2.51 | 3,470. | 271. |
| 59 | 12.8 | 10.00 | 4.27 | 6.57 | 6,550. | 512. |
| 60 | 12.8 | 12.00 | 4.27 | 12.10 | 12,350. | 965. |
| | | | | | | |
| Bow Flap with Deadrise, and Gap Wheel Covers On | | | | | | |
| - | 12.8 | 0.00 | 3.55 | - 0.57 | 0. | 0. |
| 73 | 12.8 | 6.00 | 3.80 | - | 1,690. | 132. |
| 71 | 12.8 | 8.00 | 4.04 | - | 3,120. | 244. |
| 74 | 12.8 | 10.00 | 4.07 | 7.18 | 6,040. | 472. |
| 72 | 12.8 | 12.00 | 4.01 | - | 11,360. | 887. |

## TABLE 1.2

### (Continued)

| RUN | LOAD<br>s-ton | SPEED<br>mph | DRAFT<br>ft | TRIM<br>deg | DRAG<br>lb | DRAG/LOAD<br>lb/s-ton |
|-----|------|-------|------|--------|---------|----------|
| Bow Flap with Deadrise, No Gap | | | | | | |
| 108 | 12.8 | 0.00 | 3.47 | - 0.15 | 0. | 0. |
| 109 | 12.8 | 5.99 | 3.80 | - 0.08 | 1,540. | 120. |
| 110* | 12.8 | 8.00 | - | - | - | - |
| | | | | | | |
| 61 | 12.8 | 0.00 | 3.51 | - 1.93 | 0. | 0. |
| 102 | 12.8 | 0.00 | 3.57 | - 1.69 | 0. | 0. |
| 62 | 12.8 | 4.01 | 3.67 | - 0.78 | 750. | 58. |
| 63 | 12.8 | 6.00 | 3.78 | 0.02 | 1,740. | 136. |
| 103 | 12.8 | 5.99 | 3.81 | 0.19 | 1,770. | 139. |
| 64 | 12.8 | 8.00 | 4.03 | 2.10 | 3,320. | 260. |
| 104 | 12.8 | 8.00 | 4.03 | 2.16 | 3,300. | 258. |
| 65 | 12.8 | 10.00 | 4.19 | 6.11 | 6,380. | 498. |
| 105 | 12.8 | 10.00 | 4.17 | 5.98 | 6,160. | 481. |
| 66 | 12.8 | 12.00 | 4.15 | 11.20 | 11,780. | 921. |
| | | | | | | |
| 106 | 12.8 | 0.00 | 3.58 | - 1.61 | 0. | 0. |
| 107* | 12.8 | 6.00 | 4.28 | - 8.87 | 3,130. | 244. |

Bow Flap with Deadrise, No Gap
Wheel Covers On

Bow Flap without Deadrise, with Gap
Wheel Covers On

Bow Flap without Deadrise, No Gap
Wheel Covers On

\* Bow Submerged

## TABLE 2.1

### CALM WATER PERFORMANCE

Displacement 28,000 lb, LCG 107.9 inches

Tracks Extended, Various Bow Flap Configurations

Wheel Covers Off

| RUN | LOAD s-ton | SPEED mph | DRAFT ft | TRIM deg | DRAG lb | DRAG/LOAD lb/s-ton |
|-----|-----------|-----------|----------|----------|---------|--------------------|
| | | | Bow Flap with Deadrise, and Gap | | | |
| 16 | 14.00 | 0.00 | 3.75 | 2.06 | 0. | 0. |
| 17 | 14.00 | 4.01 | 3.97 | 2.80 | 840. | 60. |
| 18 | 14.00 | 5.99 | 4.06 | 4.01 | 2,040. | 146. |
| 19 | 14.00 | 8.00 | 4.29 | 6.55 | 4,530. | 324. |
| 20 | 14.00 | 10.00 | 4.45 | 11.07 | 9,270. | 662. |
| 21 | 14.00 | 12.00 | 4.23 | 16.89 | 16,280. | 1,163. |
| | | | Bow Flap with Deadrise, No Gap | | | |
| 22 | 14.00 | 0.00 | 3.83 | 1.47 | 0. | 0. |
| 23 | 14.00 | 4.01 | 3.99 | 2.02 | 850. | 61. |
| 24 | 14.00 | 6.00 | 4.14 | 3.04 | 2,090. | 149. |
| 25 | 14.00 | 8.00 | 4.31 | 4.94 | 4,280. | 306. |
| 26 | 14.00 | 10.00 | 4.48 | 8.85 | 8,680. | 620. |
| 27 | 14.00 | 12.00 | 4.50 | 15.85 | 16,810. | 1,201. |

## TABLE 2.2

### CALM WATER PERFORMANCE

Displacement   28,000 lb, LCG   107.9 inches

Tracks Retracted, Various Bow Flap Configurations

| RUN | LOAD s-ton | SPEED mph | DRAFT ft | TRIM deg | DRAG lb | DRAG/LOAD lb/s-ton |
|-----|-----------|-----------|----------|----------|---------|---------------------|
| | | | | | | |
| | | Bow Flap with Deadrise, and Gap Wheel Covers Off | | | | |
| 41 | 14.00 | 0.00 | 3.91 | 2.08 | 0. | 0. |
| 42 | 14.00 | 4.01 | 4.01 | 2.70 | 730. | 52. |
| 43 | 14.00 | 5.99 | 4.15 | 3.64 | 1,750. | 125. |
| 44 | 14.00 | 8.00 | 4.35 | 5.81 | 3,660. | 261. |
| 45 | 14.00 | 10.00 | 4.43 | 9.86 | 7,270. | 519. |
| 46 | 14.00 | 12.00 | 4.42 | 15.73 | 14,160. | 1,012. |
| | | | | | | |
| | | Bow Flap without Deadrise, with Gap Wheel Covers Off | | | | |
| 47 | 14.00 | 0.00 | 3.95 | 1.23 | 0. | 0. |
| 48 | 14.00 | 4.01 | 4.07 | 2.12 | 810. | 58. |
| 49 | 14.00 | 6.00 | 4.21 | 3.22 | 1,880. | 135. |
| 50 | 14.00 | 8.00 | 4.40 | 5.36 | 3,780. | 270. |
| 51 | 14.00 | 10.00 | 4.49 | 9.17 | 7,290. | 521. |
| 52 | 14.00 | 12.00 | 4.53 | 15.53 | 14,440. | 1,032. |
| | | | | | | |
| | | Bow Flap with Deadrise, and Gap Wheel Covers On | | | | |
| - | 14.00 | 0.00 | 3.78 | 1.72 | 0. | 0. |
| 86 | 14.00 | 6.00 | 4.04 | 3.43 | 1,950. | 140. |
| 91 | 14.00 | 8.00 | 4.22 | 5.87 | 3,570. | 255. |
| 98 | 14.00 | 8.00 | 4.15 | 5.29 | 3,490. | 249. |
| 92 | 14.00 | 10.00 | 4.24 | 10.19 | 6,340. | 452. |

## TABLE 2.2
### (Continued)

| RUN | LOAD s-ton | SPEED mph | DRAFT ft | TRIM deg | DRAG lb | DRAG/LOAD lb/s-ton |
|---|---|---|---|---|---|---|
| | | | Bow Flap with Deadrise, No Gap Wheel Covers On | | | |
| 94 | 14.00 | 0.00 | 3.71 | 2.32 | 0. | 0. |
| 95 | 14.00 | 6.00 | 3.97 | 3.08 | 1,670. | 119. |
| 96* | 14.00 | 8.00 | - | - | - | - |
| 97* | 14.00 | 8.00 | - | - | - | - |
| | | | Bow Flap without Deadrise, with Gap Wheel Covers On | | | |
| - | 14.00 | 0.00 | 3.85 | 1.13 | 0. | 0. |
| 99 | 14.00 | 6.00 | 4.12 | 2.91 | 1,830. | 131. |
| 100 | 14.00 | 8.00 | 4.31 | 5.10 | 3,600. | 257. |
| 101 | 14.00 | 10.00 | 4.38 | 8.52 | 6,730. | 481. |

* Bow Submerged

TABLE 3.1

IRREGULAR WAVE STATISTICS

Displacement  25,600 lb, LCG  104.3 inches

Tracks Extended with Wheel Covers On

Bow Flap with Deadrise and Gap

DAVIDSON LABORATORY                                                     11-DEC-81

SMALL AMPHIBIAN (FLASH)

RUN   121

| | SPEED  6.0 MPH<br>WEIGHT  12.8 S-TONS<br>DRAG  191. LB/S-TON | | | WAVE ENCOUNTERS  56<br>SEA STATE  2<br>LCG 104.3 IN | | |
|---|---|---|---|---|---|---|
| | MEAN/RMS | OSC/BUFF | AVG | 1/3 | 1/10 | EXTREME |
| PITCH,DEG | 1.394<br>3.954 | 43<br>1.10 | 6.53<br>-3.51 | 9.20<br>-6.04 | 10.76<br>-7.26 | 12.59<br>-8.38 |
| HEAVE,FT | -1.659<br>0.545 | 37<br>0.10 | -1.03<br>-2.29 | -0.64<br>-2.66 | -0.28<br>-2.86 | -0.07<br>-3.06 |
| DRIVER, ACC | -0.007<br>0.101 | 49<br>0.10 | 0.14<br>-0.15 | 0.21<br>-0.25 | 0.28<br>-0.32 | 0.43<br>-0.43 |
| C G ACC, G | 0.005<br>0.085 | 40<br>0.10 | 0.13<br>-0.12 | 0.18<br>-0.17 | 0.21<br>-0.23 | 0.22<br>-0.29 |

TABLE 3.2

DAVIDSON LABORATORY                                          11-DEC-81
                    SMALL AMPHIBIAN (FLASH)

RUN   123

        SPEED   10.0 MPH                    WAVE ENCOUNTERS    41
        WEIGHT  12.8 S-TONS                       SEA STATE   2
        DRAG    702. LB/S-TON                     LCG 104.3 IN

            MEAN/RMS   OSC/BUFF    AVG      1/3      1/10    EXTREME

PITCH,DEG     9.715      28      14.19    16.42    17.59    18.15
              3.525     1.10      4.96     3.25     1.57     0.18

HEAVE,FT     -2.074      27      -1.59    -1.23    -0.92    -0.75
              0.441     0.10     -2.58    -2.92    -3.14    -3.39

DRIVER, ACC  -0.018      34       0.15     0.22     0.25     0.27
              0.125     0.10     -0.21    -0.30    -0.35    -0.36

C G ACC, G    0.007      27       0.15     0.21     0.27     0.32
              0.096     0.10     -0.13    -0.19    -0.23    -0.24

## TABLE 4.1

### IRREGULAR WAVE STATISTICS

Displacement 25,600 lb, LCG 104.3 inches
Tracks Retracted with Wheel Covers On
Bow Flap with Deadrise and Gap

DAVIDSON LABORATORY

SMALL AMPHIBIAN (FLASH)                    9-DEC-81

RUN    75

| | SPEED 4.0 MPH | | | WAVE ENCOUNTERS 70 | | |
| | WEIGHT 12.8 S-TONS | | | SEA STATE 2 | | |
| | DRAG 92. LB/S-TON | | | LCG 104.3 IN | | |
| | MEAN/RMS | OSC/BUFF | AVG | 1/3 | 1/10 | EXTREME |
| PITCH,DEG | 0.320 | 58 | 5.88 | 8.57 | 10.36 | 12.15 |
| | 4.230 | 1.10 | -5.44 | -7.93 | -9.77 | -10.87 |
| HEAVE,FT | | | | | | |
| DRIVER, ACC | -0.014 | 68 | 0.11 | 0.17 | 0.23 | 0.37 |
| | 0.082 | 0.10 | -0.13 | -0.21 | -0.26 | -0.34 |
| C G ACC, G | 0.002 | 50 | 0.11 | 0.16 | 0.18 | 0.19 |
| | 0.072 | 0.10 | -0.11 | -0.15 | -0.18 | -0.23 |

TR-2250

TABLE 4.2

DAVIDSON LABORATORY                                                    9-DEC-81

SMALL AMPHIBIAN (FLASH)

RUN    76

            SPEED    6.0 MPH                    WAVE ENCOUNTERS    53
            WEIGHT  12.8 S-TONS                      SEA STATE   2
            DRAG   198. LB/S-TON                     LCG 104.3 IN

            MEAN/RMS   OSC/BUFF   AVG      1/3      1/10    EXTREME

PITCH,DEG     1.129      41      6.21     9.02     11.22     12.83
              3.922     1.10    -4.00    -6.28     -7.25     -8.54

HEAVE,FT

DRIVER, ACC  -0.009      54      0.13     0.20      0.27      0.41
              0.098     0.10    -0.14    -0.24     -0.31     -0.39

C G ACC, G    0.003      39      0.13     0.19      0.23      0.24
              0.088     0.10    -0.13    -0.19     -0.22     -0.28

TABLE 4.3

DAVIDSON LABORATORY                                                    10-DEC-81

SMALL AMPHIBIAN (FLASH)

RUN     80

SPEED    7.0 MPH                          WAVE ENCOUNTERS      47
WEIGHT   12.8 S-TONS                            SEA STATE    2
DRAG     241. LB/S-TON                          LCG 104.3 IN

|            | MEAN/RMS | OSC/BUFF | AVG | 1/3 | 1/10 | EXTREME |
|------------|----------|----------|-----|-----|------|---------|
| PITCH,DEG  | 2.112    | 36       | 6.99  | 9.21  | 11.34 | 13.04   |
|            | 3.689    | 1.10     | -2.78 | -5.22 | -6.24 | -7.11   |
| HEAVE,FT   | -1.710   | 34       | -1.14 | -0.76 | -0.55 | -0.09   |
|            | 0.493    | 0.10     | -2.31 | -2.65 | -2.89 | -3.19   |
| DRIVER, ACC| -0.009   | 41       | 0.15  | 0.21  | 0.25  | 0.38    |
|            | 0.100    | 0.10     | -0.15 | -0.24 | -0.32 | -0.36   |
| C G ACC, G | -0.003   | 35       | 0.14  | 0.18  | 0.22  | 0.24    |
|            | 0.091    | 0.10     | -0.13 | -0.19 | -0.24 | -0.26   |

Note:   At 8.0 mph bow,submerged; and run was aborted.   Same
behavior occurred at 8.0 mph with tangent plate removed.

## TABLE 5

### IRREGULAR WAVE STATISTICS

Displacement  25,600 lb, LCG  104.3 inches

Tracks Retracted with Wheel Covers On

Bow Flap with Deadrise, No Gap, and

Elevated to Maximum Up Position

DAVIDSON LABORATORY                                                      9-DEC-81

SMALL AMPHIBIAN (FLASH)

RUN    79

SPEED    8.0 MPH                      WAVE ENCOUNTERS    44
WEIGHT   12.8 S-TONS                         SEA STATE   2
DRAG    351. LB/S-TON                         LCG 104.3 IN

|            | MEAN/RMS | OSC/BUFF | AVG   | 1/3   | 1/10  | EXTREME |
|------------|----------|----------|-------|-------|-------|---------|
| PITCH,DEG  | 2.149    | 32       | 7.43  | 9.54  | 11.35 | 12.92   |
|            | 3.824    | 1.10     | -3.30 | -5.10 | -6.30 | -6.67   |
| HEAVE,FT   |          |          |       |       |       |         |
| DRIVER, ACC | -0.008  | 42       | 0.15  | 0.24  | 0.30  | 0.46    |
|            | 0.109    | 0.10     | -0.16 | -0.23 | -0.27 | -0.36   |
| C G ACC, G | 0.001    | 32       | 0.15  | 0.22  | 0.26  | 0.29    |
|            | 0.099    | 0.10     | -0.14 | -0.20 | -0.24 | -0.26   |

TABLE 6.1

IRREGULAR WAVE STATISTICS

Displacement 28,000 lb, LCG 107.9 inches

Tracks Extended with Wheel Covers On

Bow Flap with Deadrise and Gap

DAVIDSON LABORATORY                                              14-DEC-81

SMALL AMPHIBIAN (FLASH)

RUN    130

SPEED    6.0 MPH                          WAVE ENCOUNTERS     54
WEIGHT   14.0 S-TONS                              SEA STATE   2
DRAG     192. LB/S-TON                            LCG   107.9 IN

|              | MEAN/RMS | OSC/BUFF | AVG   | 1/3   | 1/10  | EXTREME |
|--------------|----------|----------|-------|-------|-------|---------|
| PITCH,DEG    | 4.372    | 42       | 9.91  | 12.43 | 13.79 | 14.58   |
|              | 4.153    | 1.10     | -0.71 | -3.22 | -4.62 | -6.03   |
| HEAVE,FT     | -1.954   | 37       | -1.32 | -0.94 | -0.63 | -0.20   |
|              | 0.521    | 0.10     | -2.56 | -2.88 | -3.17 | -3.48   |
| DRIVER, ACC  | -0.011   | 53       | 0.14  | 0.21  | 0.28  | 0.41    |
|              | 0.111    | 0.10     | -0.16 | -0.26 | -0.34 | -0.39   |
| C G ACC, G   | -0.002   | 39       | 0.12  | 0.16  | 0.19  | 0.24    |
|              | 0.082    | 0.10     | -0.13 | -0.19 | -0.24 | -0.28   |

TABLE 6.2

DAVIDSON LABORATORY                                          14-DEC-81
                        SMALL AMPHIBIAN (FLASH)

RUN   131

          SPEED    8.0 MPH                  WAVE ENCOUNTERS    47
          WEIGHT  14.0 S-TONS                       SEA STATE  2
          DRAG    377. LB/S-TON                      LCG 107.9 IN

              MEAN/RMS   OSC/BUFF   AVG      1/3      1/10    EXTREME

PITCH,DEG       7.257      33     12.66    15.73    17.39    18.30
                4.249      1.10    1.65    -0.49    -1.30    -1.78

HEAVE,FT       -2.192      32     -1.60    -1.15    -0.87    -0.57
                0.525      0.10   -2.77    -3.14    -3.45    -3.67

DRIVER, ACC    -0.015      39      0.16     0.25     0.34     0.57
                0.124      0.10   -0.19    -0.28    -0.37    -0.39

C G ACC, G     -0.000      33      0.14     0.20     0.22     0.23
                0.096      0.10   -0.14    -0.20    -0.24    -0.25

TABLE 6.3

DAVIDSON LABORATORY                                        14-DEC-81

SMALL AMPHIBIAN (FLASH)

RUN   132

| | SPEED   10.0 MPH | | | WAVE ENCOUNTERS   39 | | |
| | WEIGHT  14.0 S-TONS | | | SEA STATE  2 | | |
| | DRAG    727. LB/S-TON | | | LCG 107.9 IN | | |

| | MEAN/RMS | OSC/BUFF | AVG | 1/3 | 1/10 | EXTREME |
|---|---|---|---|---|---|---|
| PITCH,DEG | 12.809 | 30 | 17.45 | 20.07 | 21.19 | 22.25 |
| | 3.892 | 1.10 | 8.03 | 5.60 | 4.67 | 3.49 |
| HEAVE,FT | -2.303 | 25 | -1.78 | -1.46 | -1.21 | -0.83 |
| | 0.449 | 0.10 | -2.84 | -3.17 | -3.45 | -3.51 |
| DRIVER, ACC | -0.026 | 35 | 0.16 | 0.23 | 0.27 | 0.33 |
| | 0.131 | 0.10 | -0.20 | -0.29 | -0.32 | -0.33 |
| C G ACC, G | 0.001 | 30 | 0.14 | 0.21 | 0.24 | 0.26 |
| | 0.095 | 0.10 | -0.13 | -0.19 | -0.23 | -0.25 |

TABLE 7.1

IRREGULAR WAVE STATISTICS

Displacement  28,000 lb, LCG  107.9 inches

Tracks Retracted with Wheel Covers On

Bow Flap with Deadrise and Gap

DAVIDSON LABORATORY                                          10-DEC-81

SMALL AMPHIBIAN (FLASH)

RUN    82

SPEED    4.0 MPH                    WAVE ENCOUNTERS      70
WEIGHT   14.0 S-TONS                       SEA STATE   2
DRAG     134. LB/S-TON                      LCG 107.9 IN

| | MEAN/RMS | OSC/BUFF | AVG | 1/3 | 1/10 | EXTREME |
|---|---|---|---|---|---|---|
| PITCH,DEG | 3.589 | 57 | 9.73 | 12.77 | 14.99 | 17.10 |
| | 4.622 | 1.10 | -2.67 | -5.36 | -6.65 | -8.19 |
| HEAVE,FT | -1.729 | 51 | -1.06 | -0.70 | -0.48 | -0.15 |
| | 0.532 | 0.10 | -2.40 | -2.76 | -2.93 | -3.11 |
| DRIVER, ACC | -0.014 | 66 | 0.13 | 0.18 | 0.24 | 0.48 |
| | 0.096 | 0.10 | -0.15 | -0.24 | -0.27 | -0.30 |
| C G ACC, G | 0.002 | 51 | 0.11 | 0.15 | 0.17 | 0.19 |
| | 0.071 | 0.10 | -0.11 | -0.15 | -0.17 | -0.20 |

TABLE 7.2

DAVIDSON LABORATORY                                      10-DEC-81

SMALL AMPHIBIAN (FLASH)

RUN   83

SPEED   6.0 MPH                    WAVE ENCOUNTERS    56
WEIGHT  14.0 S-TONS                      SEA STATE   2
DRAG    215. LB/S-TON                    LCG 107.9 IN

| | MEAN/RMS | OSC/BUFF | AVG | 1/3 | 1/10 | EXTREME |
|---|---|---|---|---|---|---|
| PITCH,DEG | 4.716 | 41 | 10.14 | 12.71 | 13.90 | 15.54 |
| | 4.166 | 1.10 | -0.93 | -3.16 | -4.60 | -5.44 |
| HEAVE,FT | -1.925 | 39 | -1.31 | -0.92 | -0.75 | -0.41 |
| | 0.515 | 0.10 | -2.54 | -2.92 | -3.29 | -3.45 |
| DRIVER, ACC | -0.014 | 64 | 0.14 | 0.22 | 0.29 | 0.40 |
| | 0.107 | 0.10 | -0.13 | -0.24 | -0.29 | -0.35 |
| C G ACC, G | 0.002 | 40 | 0.12 | 0.17 | 0.21 | 0.25 |
| | 0.081 | 0.10 | -0.12 | -0.18 | -0.20 | -0.22 |

TABLE 7.3

DAVIDSON LABORATORY                                      10-DEC-81
                    SMALL AMPHIBIAN (FLASH)

RUN    84

           SPEED    7.0 MPH              WAVE ENCOUNTERS     46
           WEIGHT  14.0 S-TONS                  SEA STATE   2
           DRAG    274. LB/S-TON                LCG 107.9 IN

           MEAN/RMS   OSC/BUFF   AVG      1/3      1/10     EXTREME

PITCH,DEG     5.713      37     11.03    13.42    15.05     15.26
              4.014     1.10     0.62    -1.89    -3.53     -4.36

HEAVE,FT     -2.067      35     -1.46    -1.02    -0.72     -0.51
              0.527     0.10    -2.68    -3.06    -3.38     -3.58

DRIVER, ACC  -0.015      41      0.16     0.23     0.29      0.55
              0.111     0.10    -0.18    -0.28    -0.35     -0.42

C G ACC, G    0.003      35      0.14     0.19     0.22      0.23
              0.088     0.10    -0.12    -0.19    -0.23     -0.27

TABLE 7.4

DAVIDSON LABORATORY                                              10-DEC-81

SMALL AMPHIBIAN (FLASH)

RUN    85

SPEED     8.0 MPH                           WAVE ENCOUNTERS    45
WEIGHT   14.0 S-TONS                              SEA STATE  2
DRAG     359. LB/S-TON                            LCG 107.9 IN

|  | MEAN/RMS | OSC/BUFF | AVG | 1/3 | 1/10 | EXTREME |
|---|---|---|---|---|---|---|
| PITCH,DEG | 7.028 | 32 | 12.54 | 15.04 | 16.71 | 17.38 |
|  | 4.068 | 1.10 | 1.44 | -0.71 | -1.89 | -2.26 |
| HEAVE,FT | -2.164 | 32 | -1.55 | -1.12 | -0.85 | -0.46 |
|  | 0.539 | 0.10 | -2.78 | -3.21 | -3.45 | -3.63 |
| DRIVER, ACC | -0.017 | 45 | 0.16 | 0.26 | 0.38 | 0.71 |
|  | 0.116 | 0.10 | -0.17 | -0.26 | -0.30 | -0.35 |
| C G ACC, G | 0.004 | 34 | 0.15 | 0.21 | 0.25 | 0.28 |
|  | 0.097 | 0.10 | -0.13 | -0.19 | -0.22 | -0.26 |

TABLE 7.5

DAVIDSON LABORATORY                                        10-DEC-81
                    SMALL AMPHIBIAN (FLASH)

RUN    87

            SPEED    9.0 MPH              WAVE ENCOUNTERS    41
            WEIGHT  14.0 S-TONS                    SEA STATE  2
            DRAG    423. LB/S-TON                  LCG 107.9 IN

| | MEAN/RMS | OSC/BUFF | AVG | 1/3 | 1/10 | EXTREME |
|---|---|---|---|---|---|---|
| PITCH,DEG | 8.843 | 34 | 13.99 | 16.71 | 18.84 | 20.06 |
| | 3.978 | 1.10 | 4.19 | 1.62 | 0.14 | -0.75 |
| HEAVE,FT | -2.226 | 33 | -1.67 | -1.22 | -0.97 | -0.79 |
| | 0.509 | 0.10 | -2.76 | -3.15 | -3.44 | -3.68 |
| DRIVER, ACC | -0.017 | 49 | 0.15 | 0.25 | 0.34 | 0.50 |
| | 0.124 | 0.10 | -0.16 | -0.27 | -0.33 | -0.37 |
| C G ACC, G | 0.006 | 34 | 0.15 | 0.22 | 0.26 | 0.30 |
| | 0.100 | 0.10 | -0.14 | -0.20 | -0.24 | -0.24 |

TABLE 7.6

DAVIDSON LABORATORY                                           10-DEC-81
                     SMALL AMPHIBIAN (FLASH)

RUN    88

        SPEED   10.0 MPH                    WAVE ENCOUNTERS    39
        WEIGHT  14.0 S-TONS                        SEA STATE   2
        DRAG    569. LB/S-TON                       LCG 107.9 IN

|  | MEAN/RMS | OSC/BUFF | AVG | 1/3 | 1/10 | EXTREME |
|---|---|---|---|---|---|---|
| PITCH, DEG | 11.840 | 28 | 16.75 | 19.09 | 21.16 | 23.40 |
|  | 3.944 | 1.10 | 6.74 | 4.41 | 2.91 | 1.75 |
| HEAVE, FT | -2.246 | 26 | -1.74 | -1.42 | -1.15 | -0.63 |
|  | 0.462 | 0.10 | -2.78 | -3.15 | -3.38 | -3.65 |
| DRIVER, ACC | -0.026 | 37 | 0.16 | 0.24 | 0.28 | 0.31 |
|  | 0.131 | 0.10 | -0.20 | -0.32 | -0.38 | -0.43 |
| C G ACC, G | -0.002 | 30 | 0.14 | 0.22 | 0.27 | 0.31 |
|  | 0.099 | 0.10 | -0.14 | -0.21 | -0.26 | -0.30 |

TABLE 7.7

DAVIDSON LABORATORY                                                    10-DEC-81

SMALL AMPHIBIAN (FLASH)

RUN    89

SPEED   11.0 MPH                          WAVE ENCOUNTERS     47
WEIGHT  14.0 S-TONS                           SEA STATE   2
DRAG    748. LB/S-TON                          LCG 107.9 IN

| | MEAN/RMS | OSC/BUFF | AVG | 1/3 | 1/10 | EXTREME |
|---|---|---|---|---|---|---|
| PITCH,DEG | 15.199 | 35 | 19.52 | 22.08 | 23.25 | |
| | 3.763 | 1.10 | 10.83 | 8.52 | 7.17 | 6.02 |
| HEAVE,FT | -2.239 | 35 | -1.80 | -1.46 | -1.23 | -0.97 |
| | 0.408 | 0.10 | -2.62 | -2.92 | -3.23 | -3.52 |
| DRIVER, ACC | -0.028 | 36 | 0.17 | 0.25 | 0.29 | 0.34 |
| | 0.135 | 0.10 | -0.23 | -0.33 | -0.38 | -0.40 |
| C G ACC, G | 0.002 | 32 | 0.15 | 0.21 | 0.24 | 0.27 |
| | 0.092 | 0.10 | -0.14 | -0.20 | -0.25 | -0.29 |

TABLE 7.8

DAVIDSON LABORATORY                                           10-DEC-81
                        SMALL AMPHIBIAN (FLASH)

RUN    90

| | SPEED 12.0 MPH | | | WAVE ENCOUNTERS 35 | | |
| | WEIGHT 14.0 S-TONS | | | SEA STATE 2 | | |
| | DRAG 1031. LB/S-TON | | | LCG 107.9 IN | | |

| | MEAN/RMS | OSC/BUFF | AVG | 1/3 | 1/10 | EXTREME |
|---|---|---|---|---|---|---|
| PITCH,DEG | | | | | | |
| | | | | | | |
| HEAVE,FT | -2.154 | 23 | -1.85 | -1.66 | -1.49 | -1.30 |
| | 0.277 | 0.10 | -2.46 | -2.75 | -2.97 | -3.08 |
| DRIVER, ACC | -0.045 | 29 | 0.15 | 0.25 | 0.30 | 0.33 |
| | 0.120 | 0.10 | -0.21 | -0.29 | -0.33 | -0.36 |
| C G ACC, G | -0.000 | 21 | 0.11 | 0.17 | 0.20 | 0.23 |
| | 0.065 | 0.10 | -0.11 | -0.15 | -0.18 | -0.19 |

TR-2250

TABLE 8

VIDEO SCENARIO

| RUN | FOOTAGE | RUN | FOOTAGE | RUN | FOOTAGE | RUN | FOOTAGE |
|---|---|---|---|---|---|---|---|
| Titles | 0 | 36 | 137 | 67 | 229 | 103 | 346 |
| 2 | 5 | 37 | 144 | 68 | 239 | 104 | 349 |
| 3 | 13 | 38 | 149 | 69 | 245 | 105 | 352 |
| 4 | 23 | 39 | 155 | 75 | 250 | 107 | 354 |
| 5 | 29 | 40 | 157 | 76 | 260 | 109 | 357 |
| 6 | 33 | 42 | 160 | 77 | 267 | 110 | 360 |
| 8 | 37 | 43 | 164 | 78 | 271 | 112 | 362 |
| 9 | 40 | 44 | 168 | 79 | 274 | 113 | 368 |
| 11 | 44 | 45 | 172 | 80 | 279 | 114 | 373 |
| 12 | 50 | 46 | 175 | 81 | 285 | 115 | 378 |
| 13 | 54 | 48 | 177 | 82 | 287 | 116 | 383 |
| 17 | 58 | 49 | 181 | 83 | 296 | 117 | 388 |
| 18 | 67 | 50 | 186 | 84 | 303 | 118 | 391 |
| 19 | 73 | 51 | 189 | 85 | 308** | 119 | 395 |
| 20 | 77* | 52 | 191 | 87 | 314 | 121 | 398 |
| 21 | 81 | 54 | 193 | 88 | 318 | 122 | 404 |
| 23 | 84 | 55 | 199 | 89 | 322 | 123 | 410 |
| 24 | 92 | 56 | 203 | 90 | 325 | 124 | 413 |
| 25 | 97 | 59 | 206 | 95 | 329 | 126 | 420 |
| 26 | 101 | 60 | 208 | 96 | 330 | 127 | 426 |
| 27 | 104 | 62 | 211 | 97 | 332 | 128 | 433 |
| 29 | 107 | 63 | 215 | 98 | 333 | 129 | 438 |
| 31 | 113 | 64 | 219 | 99 | 340 | 130 | 444 |
| 32 | 118 | 65 | 222 | 100 | 342 | 131 | 449 |
| 33 | 122 | 66 | 225 | 101 | 344 | 132 | 453 |
| 35 | 126 | | | | | | |

Note:  *Run 19 on Video

**Actual speed 7 mph, 8 mph on video

STERN VIEW

SIDE VIEW
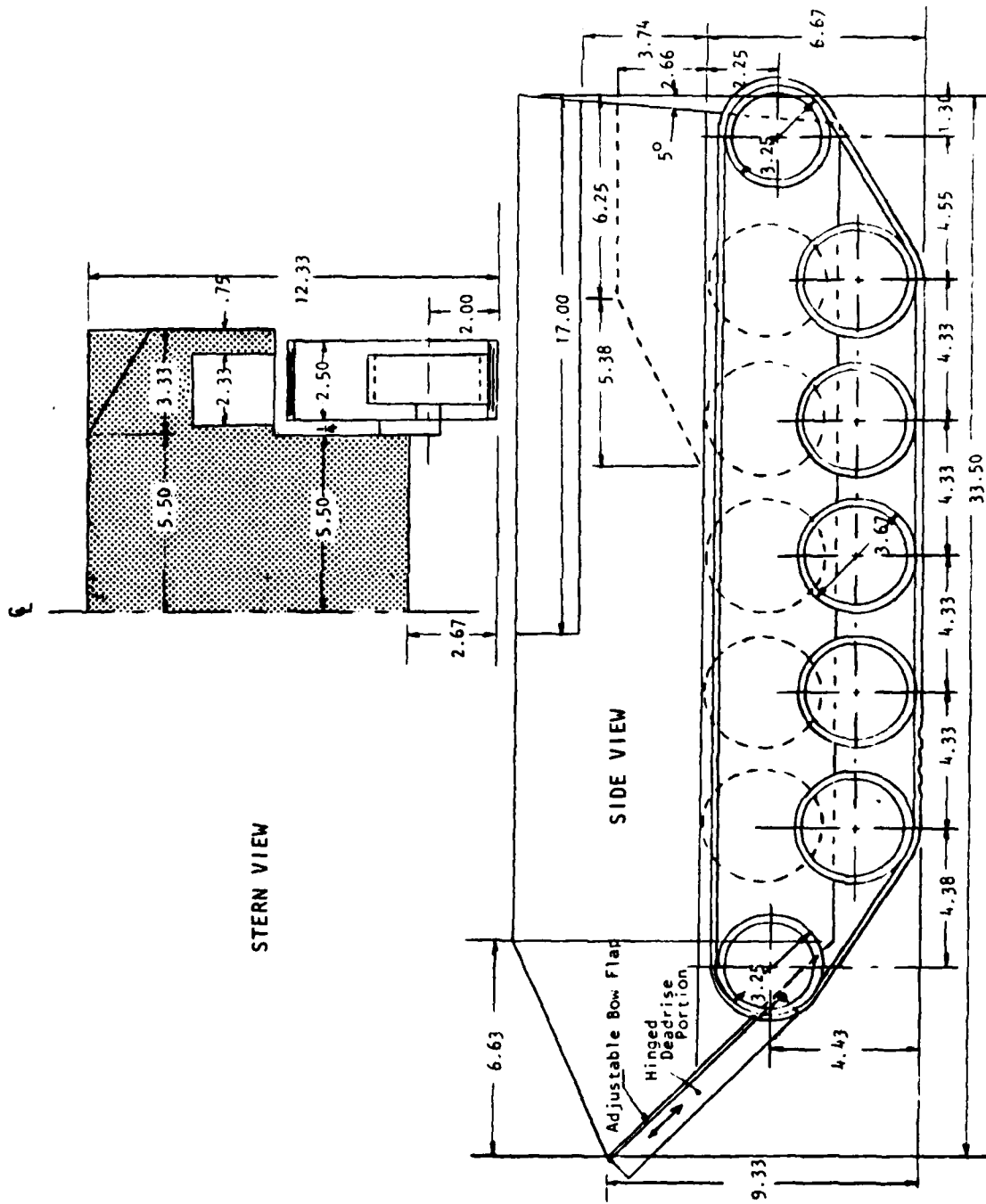
FIGURE 1  PRINCIPAL DIMENSIONS OF "FLASH" MODEL  (INCHES)

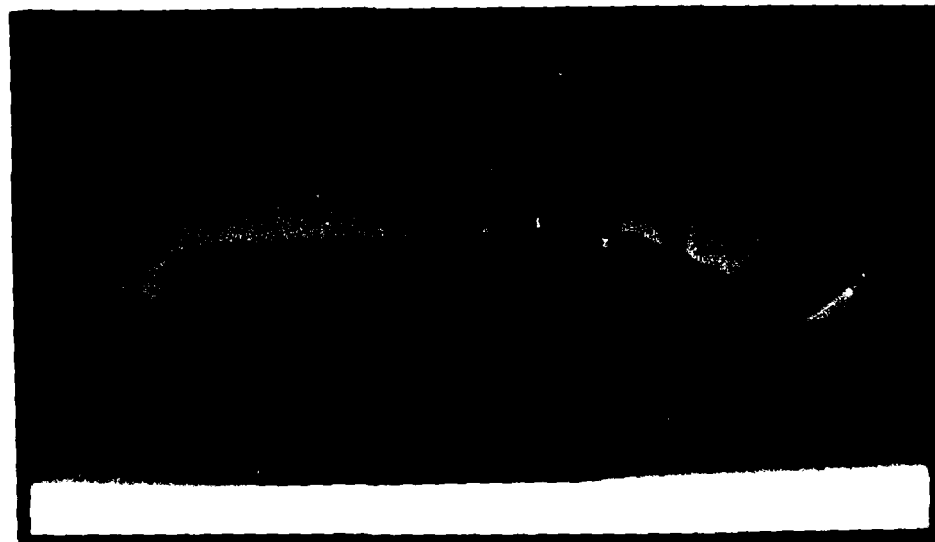FIGURE 2   SMALL AMPHIBIAN MODEL-1/6 SCALE

SPEED 6 MPH

BOW FLAP WITH DEADRISE, NO GAP



SPEED 10 MPH

BOW FLAP WITH DEADRISE AND GAP

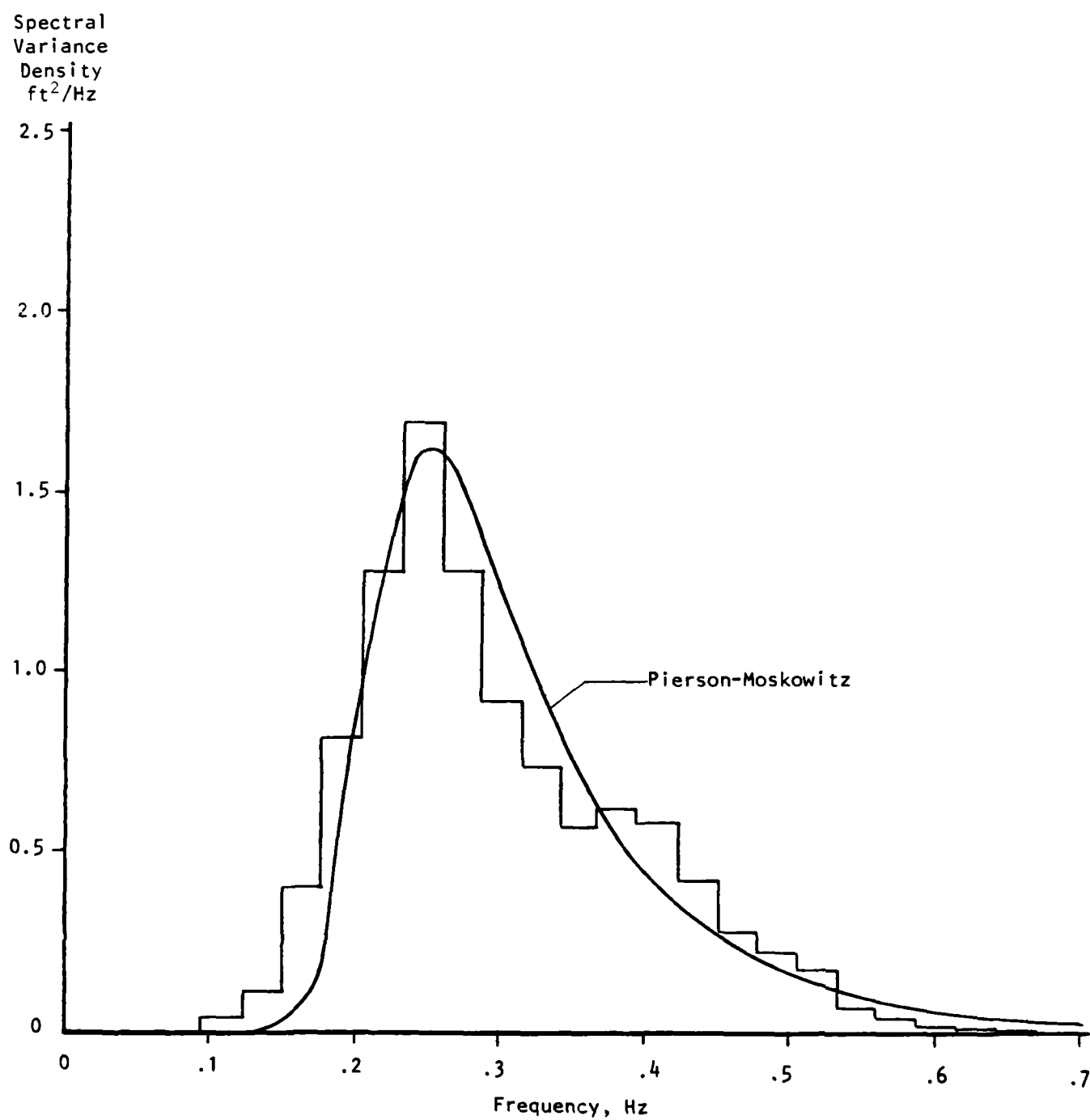FIGURE 3  SMALL AMPHIBIAN MODEL AT SPEED

28,000 LB. DISPLACEMENT

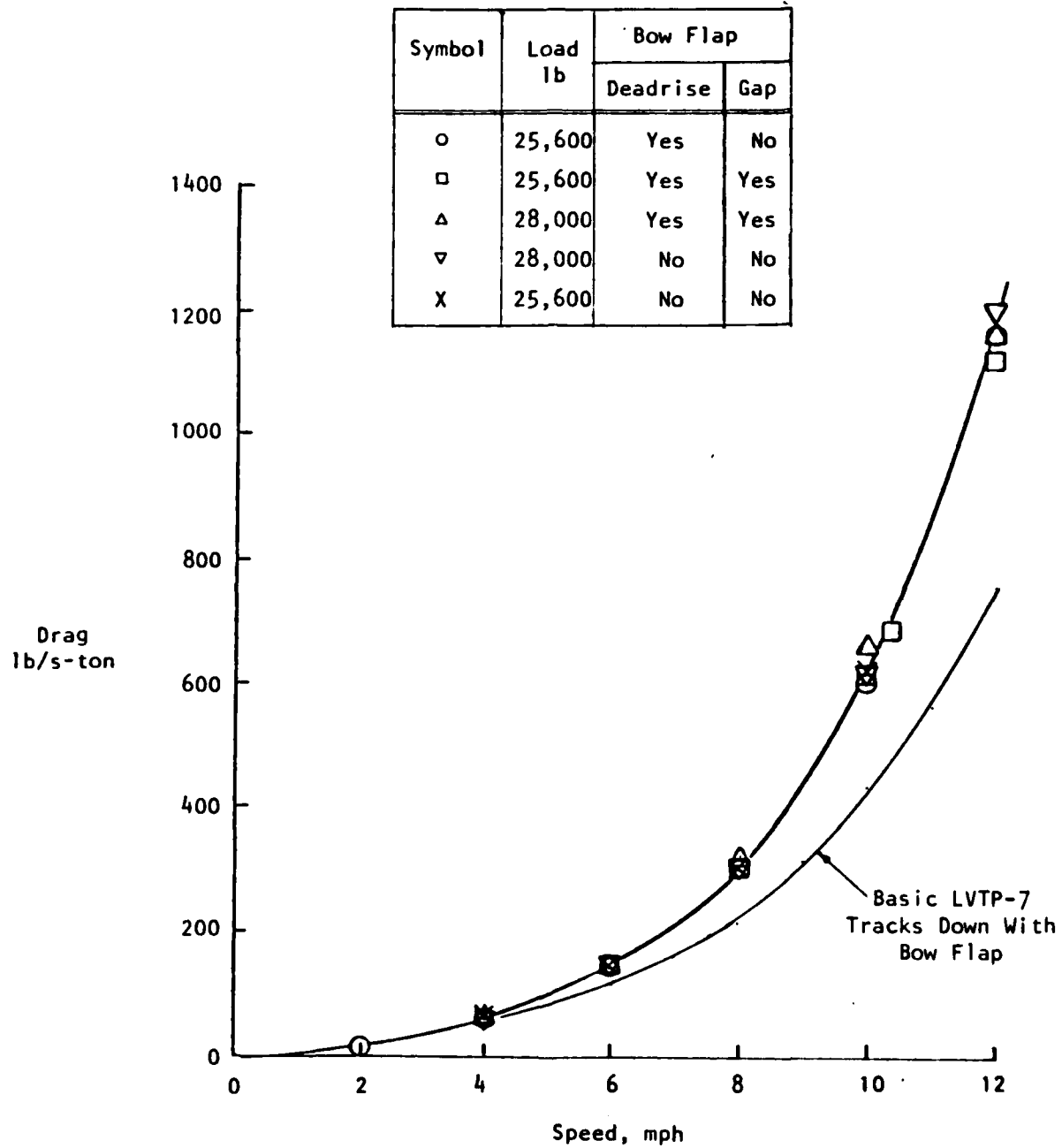FIGURE 4   EXPERIMENTAL WAVE SPECTRUM, SIGNIFICANT HEIGHT 2.2 FT

| Symbol | Load lb | Bow Flap | |
|--------|---------|----------|-----|
| | | Deadrise | Gap |
| o | 25,600 | Yes | No |
| □ | 25,600 | Yes | Yes |
| △ | 28,000 | Yes | Yes |
| ▽ | 28,000 | No | No |
| X | 25,600 | No | No |



Basic LVTP-7
Tracks Down With
Bow Flap

Drag
lb/s-ton

Speed, mph

FIGURE 5   CALM WATER DRAG PERFORMANCE
TRACKS EXTENDED WITH WHEEL COVERS OFF

| Symbol | Load lb | Bow Flap | |
|--------|---------|----------|-----|
| | | Deadrise | Gap |
| o | 25,600 | Yes | Yes |
| □ | 28,000 | Yes | Yes |
| △ | 28,000 | No | Yes |
| ▽ | 25,600 | No | Yes |
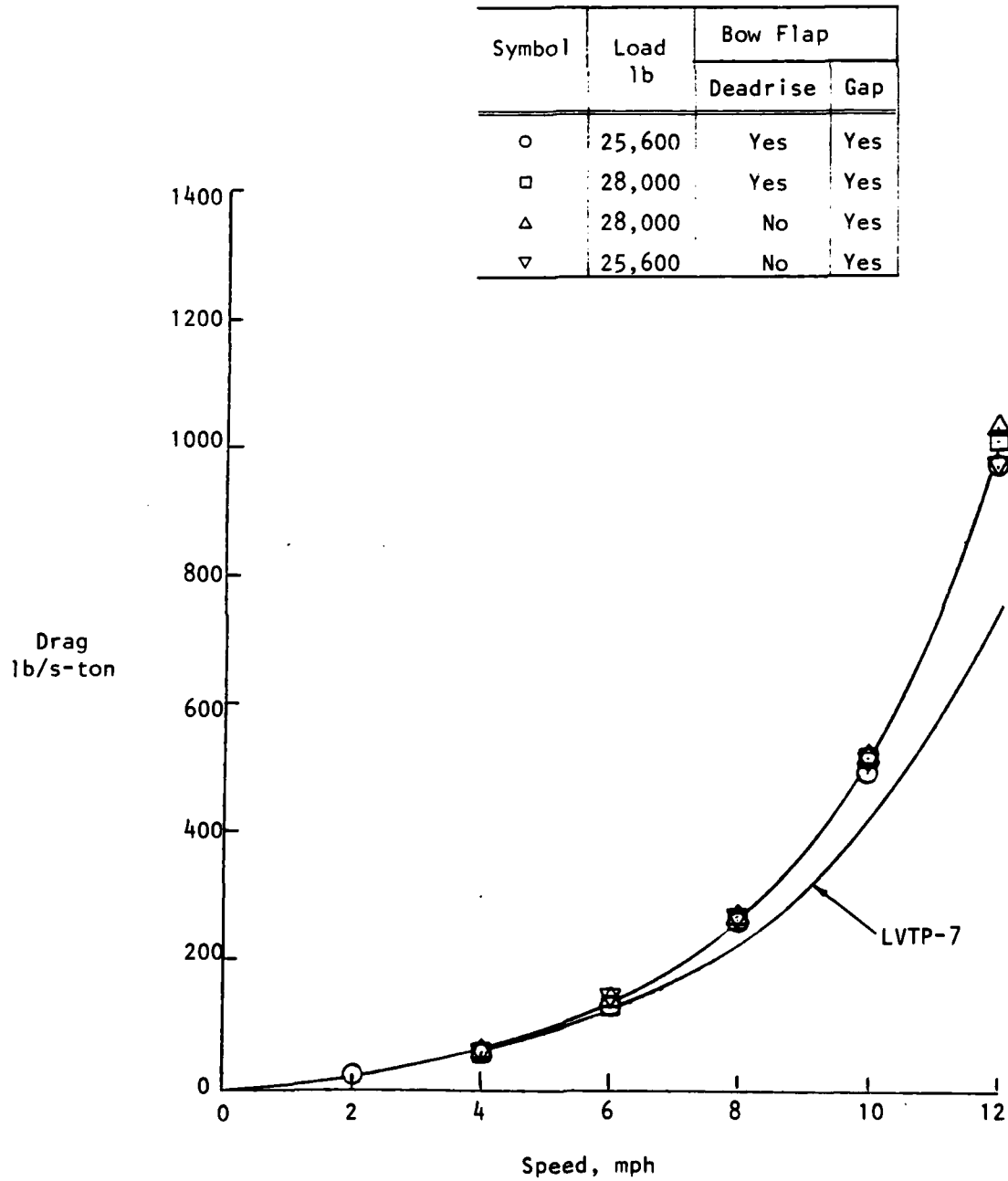


FIGURE 6   CALM WATER DRAG PERFORMANCE
TRACKS RETRACTED WITHOUT WHEEL COVERS

| Symbol | Load lb | Bow Flap | |
|---|---|---|---|
| | | Deadrise | Gap |
| O | 25,600 | No | Yes |
| □ | 25,600 | Yes | Yes |
| △ | 28,000 | Yes | Yes |
| ▽ | 28,000 | No | Yes |
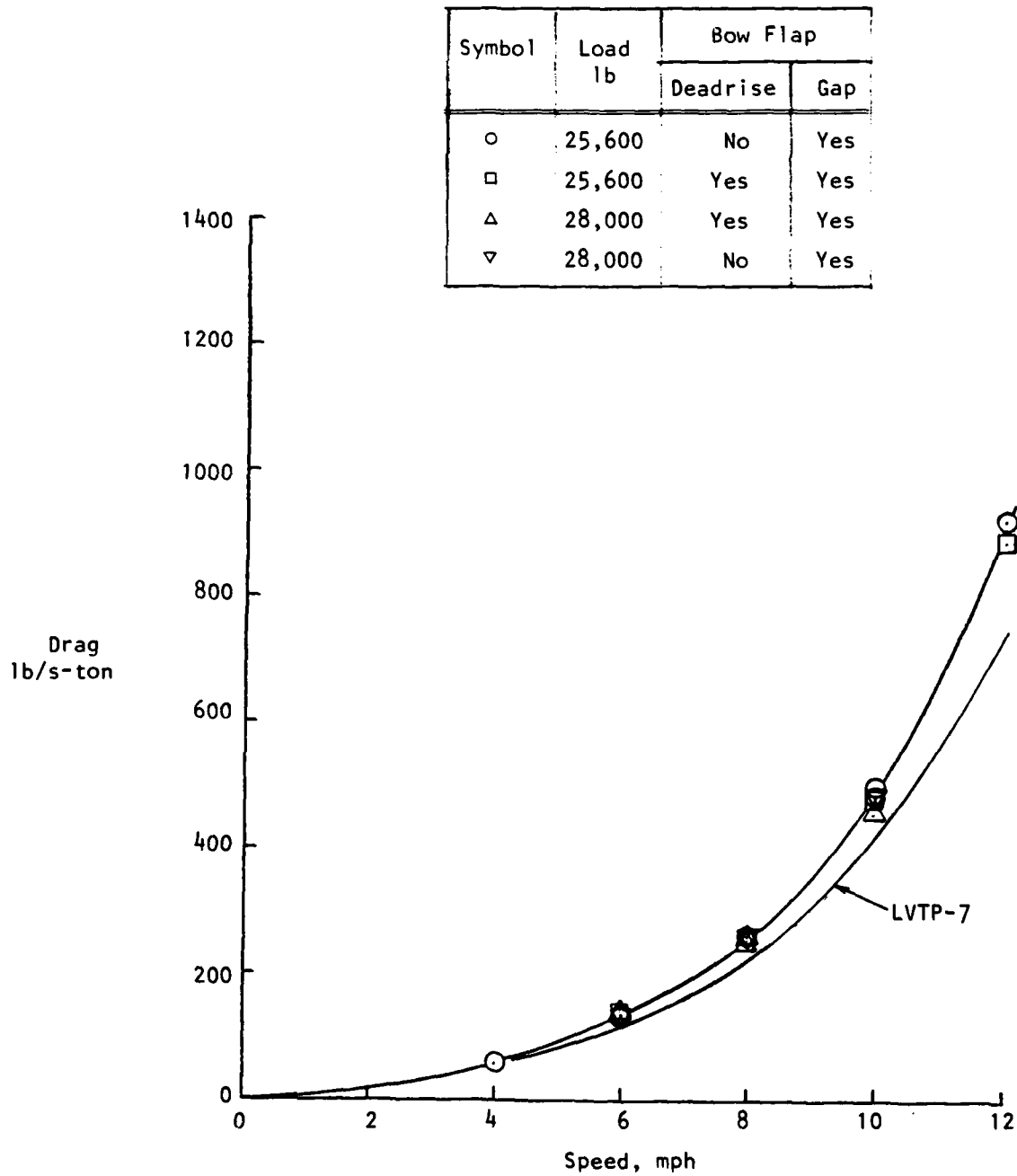


FIGURE 7   CALM WATER DRAG PERFORMANCE
TRACKS RETRACTED WITH WHEEL COVERS ON

| Symbol | Load lb | Bow Flap | |
| --- | --- | --- | --- |
| | | Deadrise | Gap |
| o | 25,600 | Yes | No |
| □ | 25,600 | Yes | Yes |
| △ | 28,000 | Yes | Yes |
| ▽ | 28,000 | No | No |
| X | 25,600 | No | No |

FIGURE 8   CALM WATER TRIM PERFORMANCE
TRACKS EXTENDED WITH WHEEL COVERS OFF

| Symbol | Load lb | Bow Flap | |
|--------|---------|----------|-----|
| | | Deadrise | Gap |
| ○ | 25,600 | Yes | Yes |
| □ | 28,000 | Yes | Yes |
| △ | 28,000 | No | Yes |
| ▽ | 25,600 | No | Yes |
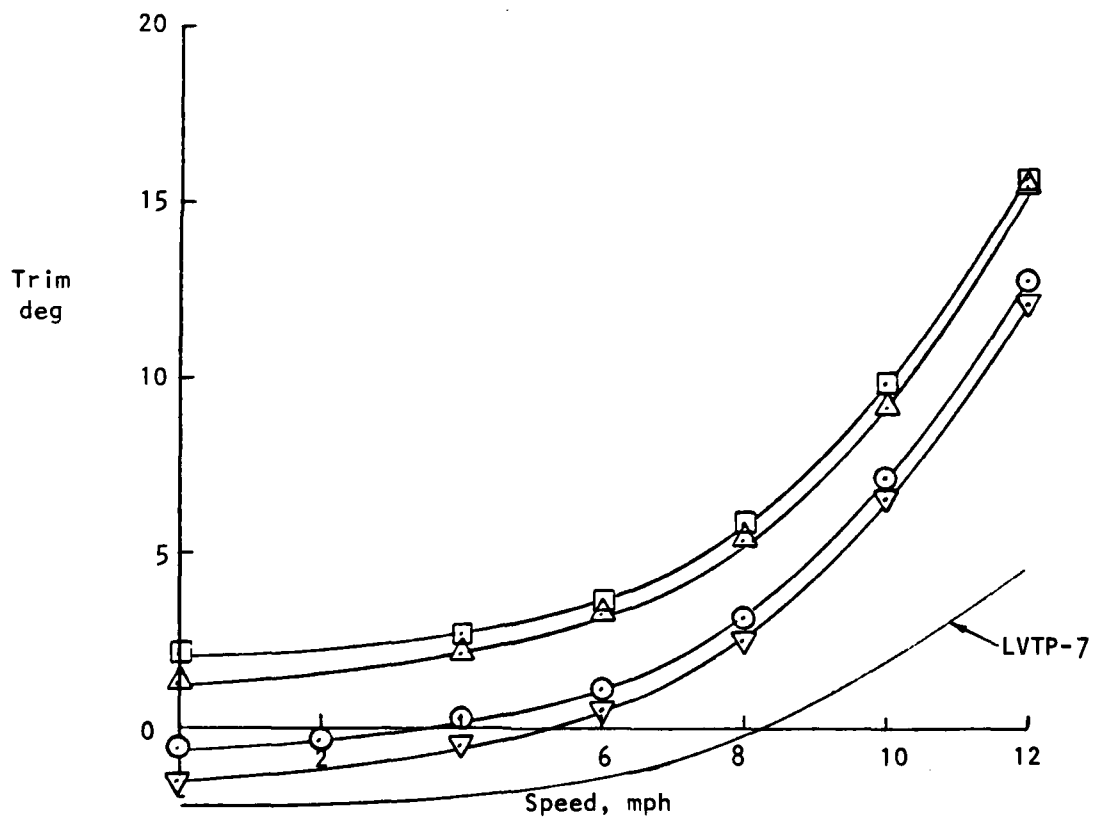
FIGURE 9   CALM WATER TRIM PERFORMANCE
TRACKS RETRACTED WITHOUT WHEEL COVERS

| Symbol | Load lb | Bow Flap | |
|--------|---------|----------|-----|
| | | Deadrise | Gap |
| O | 25,600 | No | Yes |
| □ | 25,600 | Yes | Yes |
| △ | 28,000 | Yes | Yes |
| ▽ | 28,000 | No | Yes |
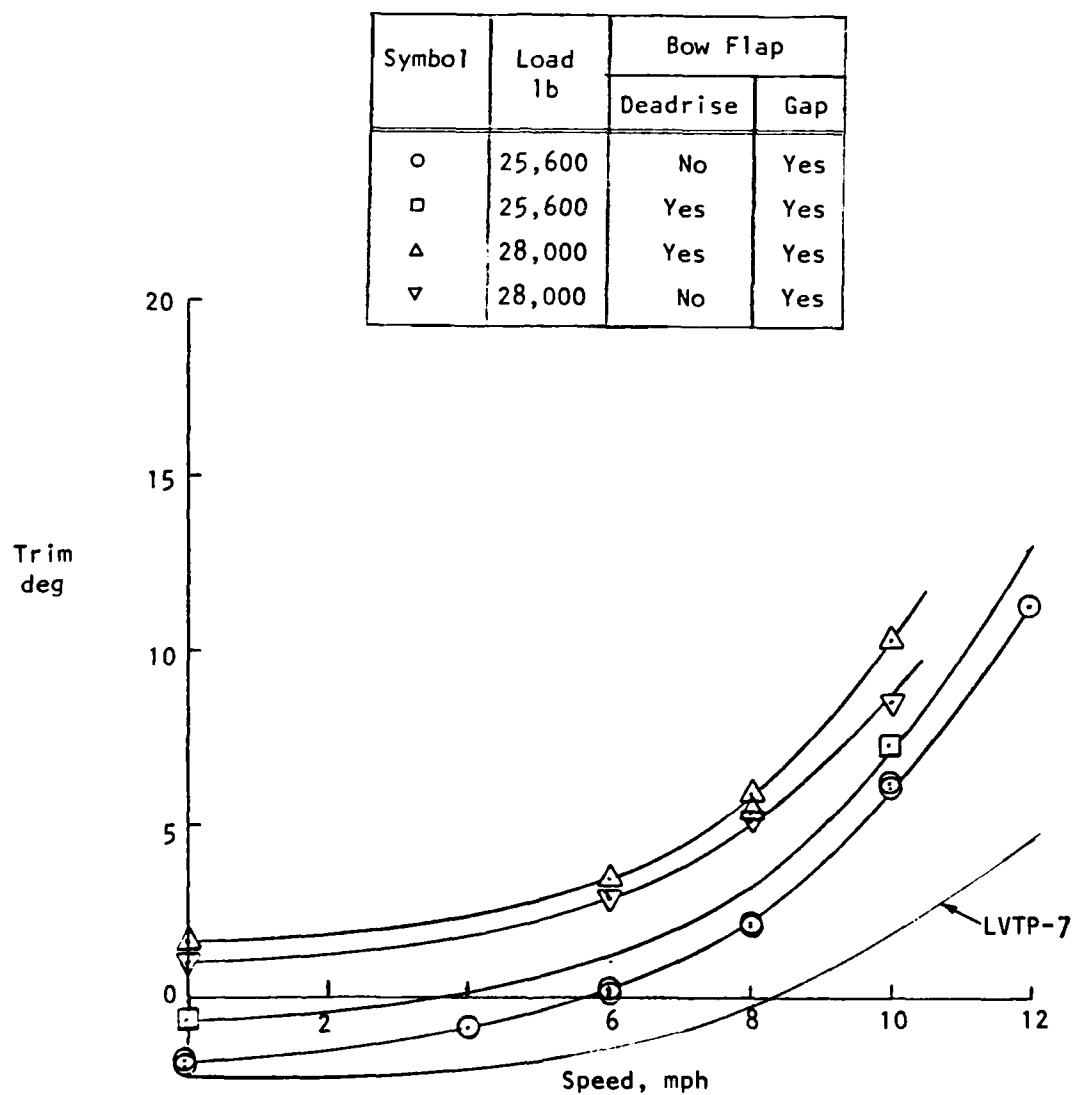


FIGURE 10 CALM WATER TRIM PERFORMANCE
TRACKS RETRACTED WITH WHEEL COVERS ON

| Symbol | Load, lb |
|:------:|:--------:|
| ○ | 25,600 |
| □ | 28,000 |
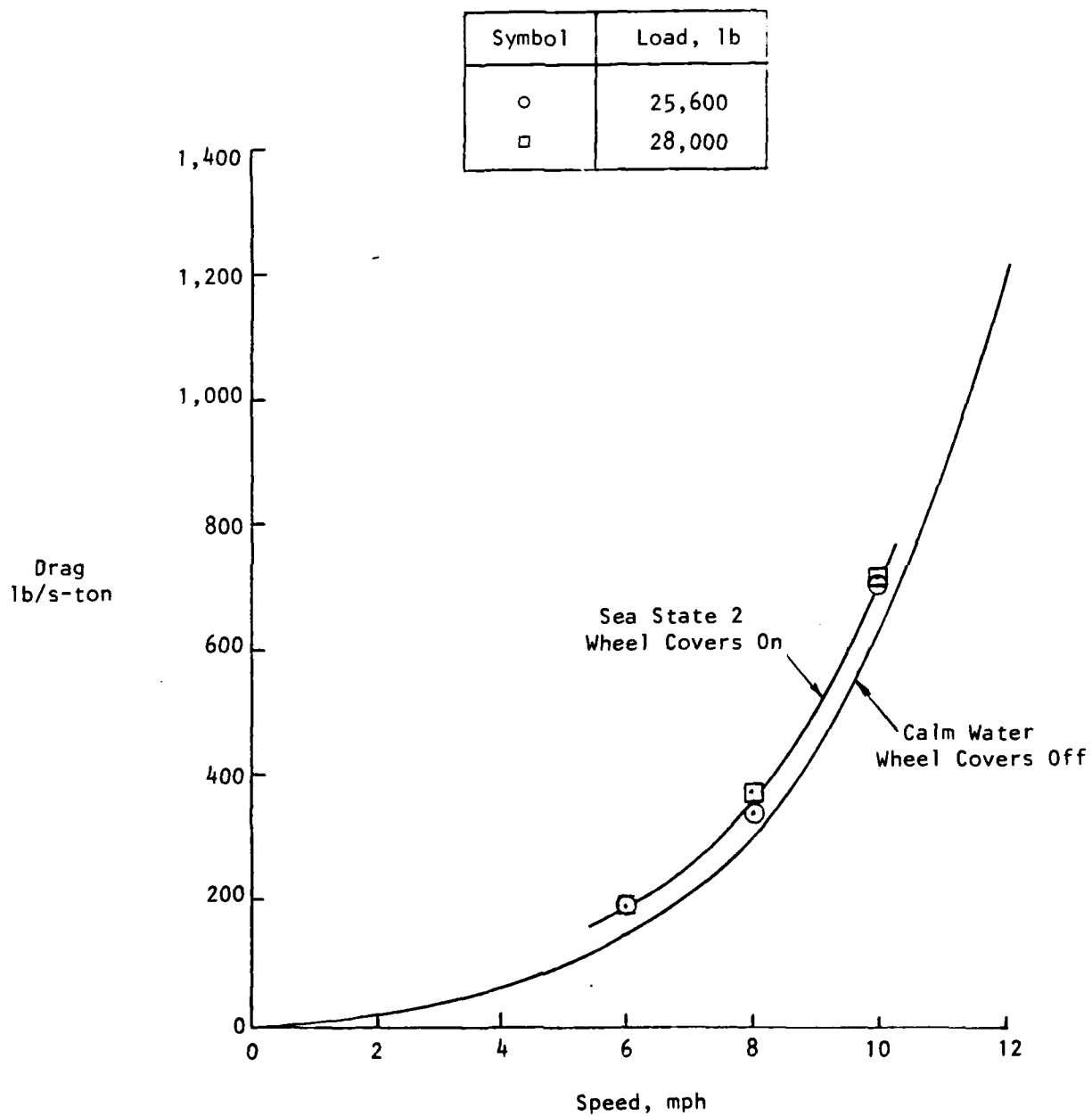


FIGURE 11 ROUGH WATER DRAG PERFORMANCE
TRACKS EXTENDED, BOW FLAP WITH DEADRISE AND GAP

| Symbol | Load, lb |
|--------|----------|
| o | 25,600* |
| □ | 28,000 |

*Note: At 8 mph run was aborted due to bow submergence
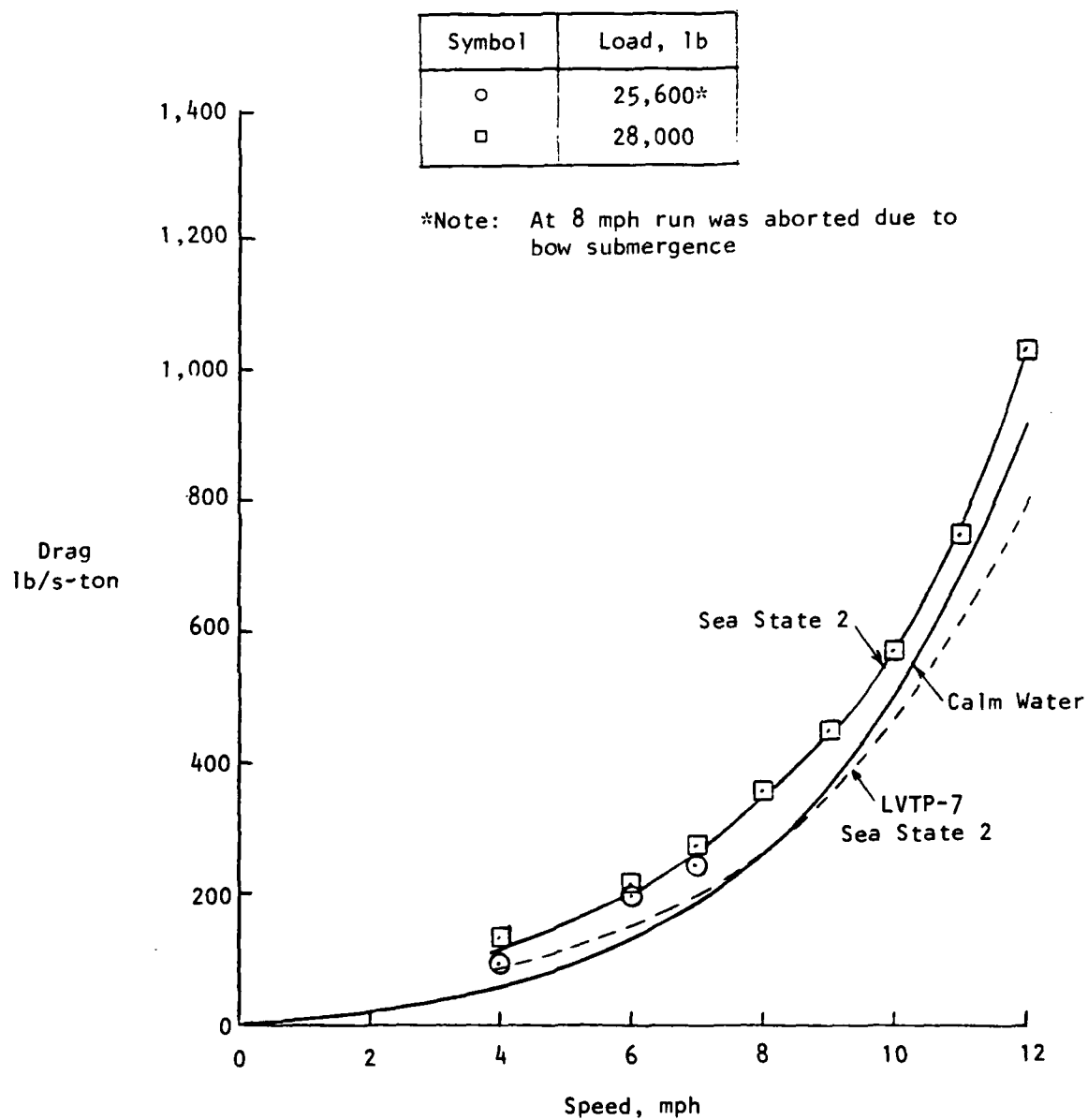
FIGURE 12 ROUGH WATER DRAG PERFORMANCE

TRACKS RETRACTED, WHEEL COVERS ON, BOW FLAP WITH DEADRISE AND GAP
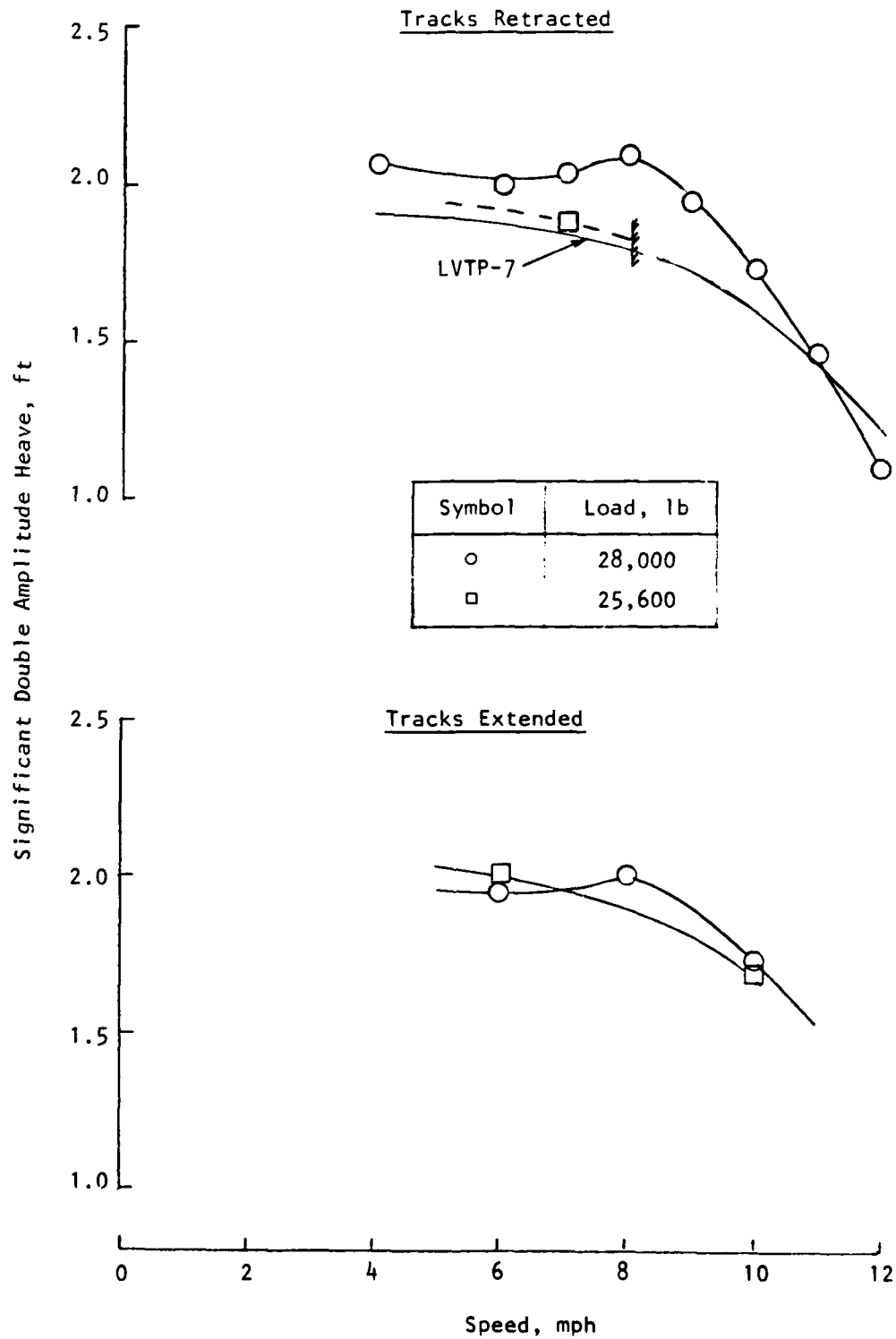
FIGURE 13 SIGNIFICANT HEAVE MOTIONS IN SEA STATE 2
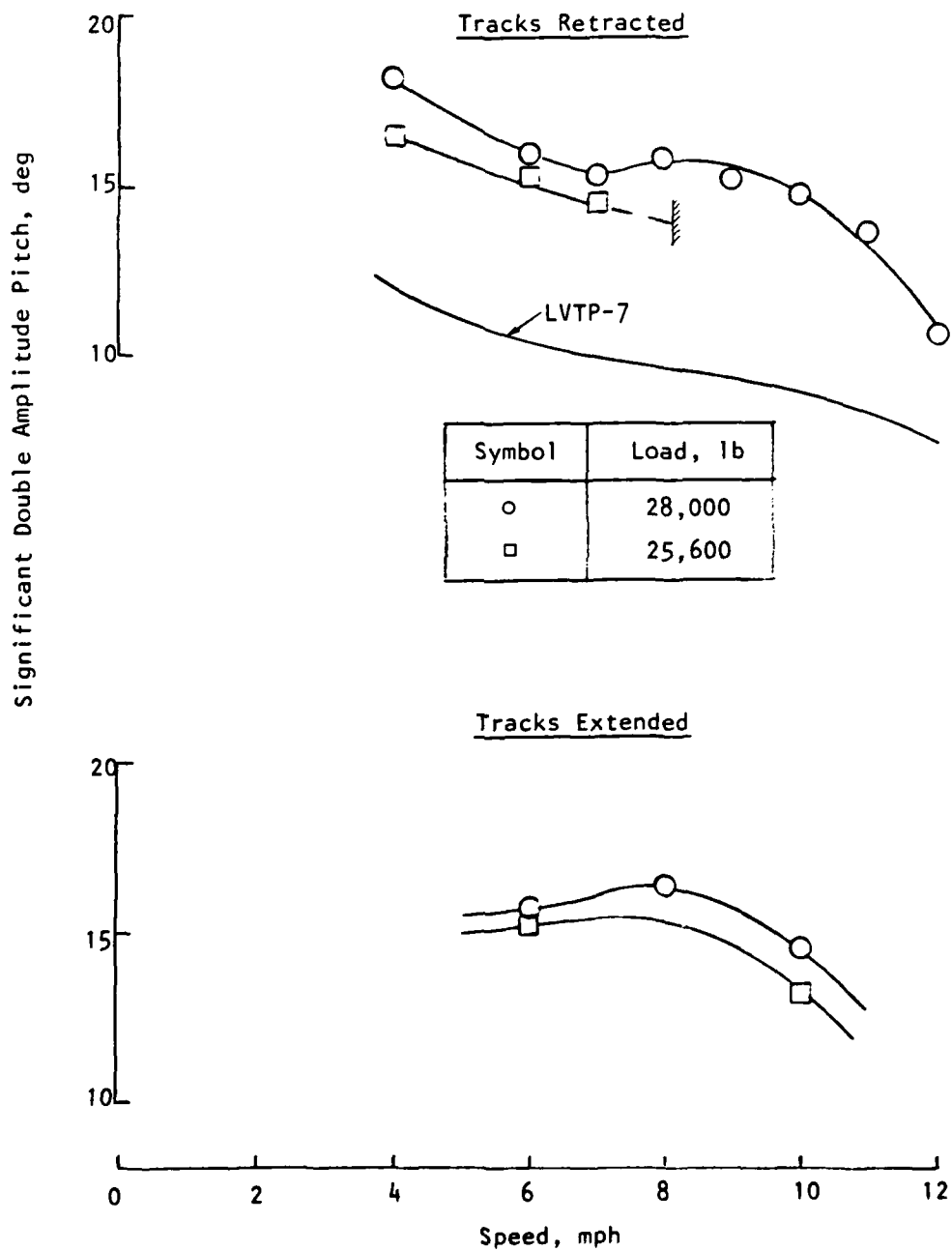BOW FLAP WITH DEADRISE AND GAP, WHEEL COVERS ON

FIGURE 14 SIGNIFICANT PITCH MOTIONS IN SEA STATE 2
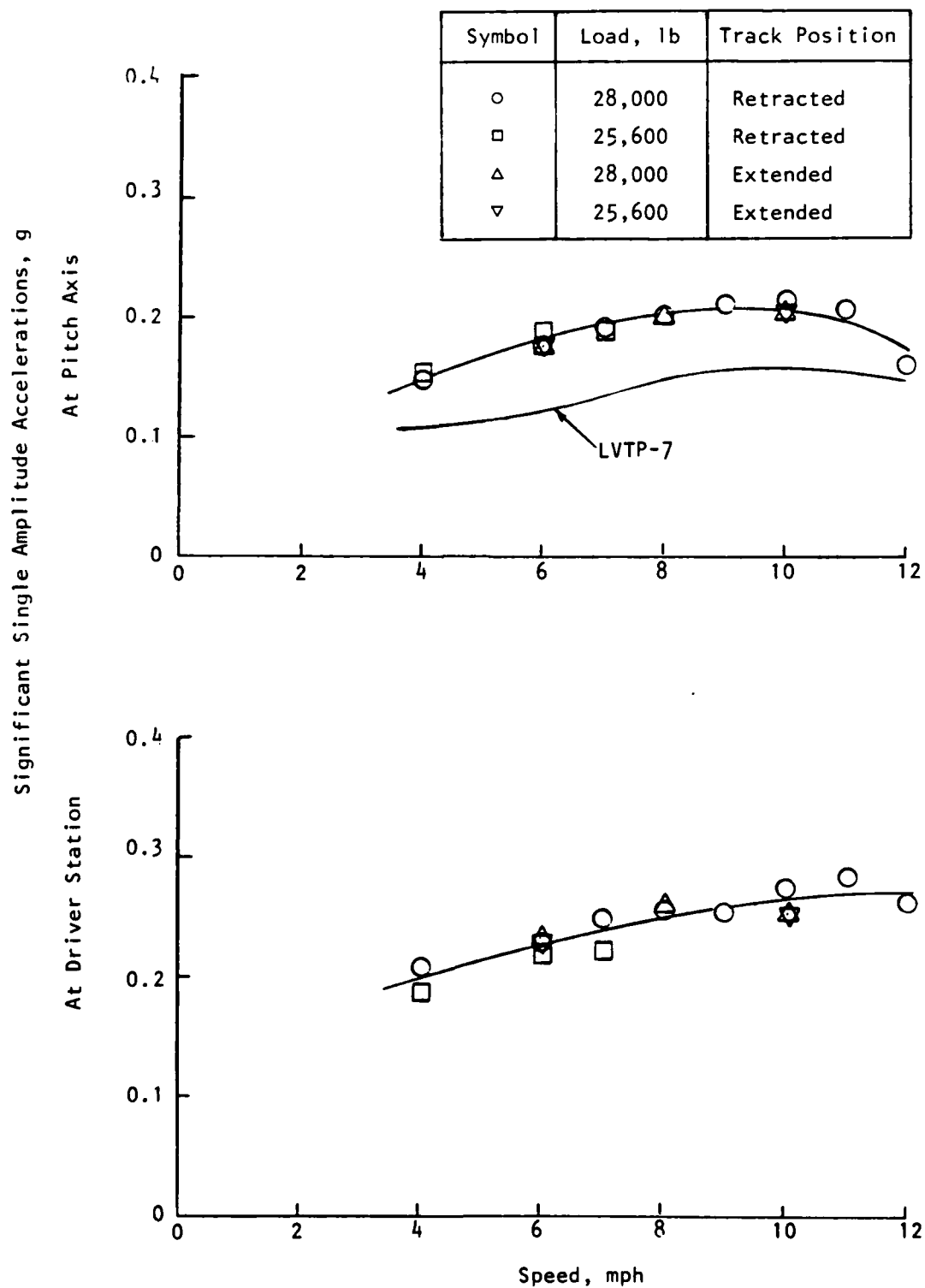BOW FLAP WITH DEADRISE AND GAP, WHEEL COVERS ON

FIGURE 15 SIGNIFICANT ACCELERATIONS IN SEA STATE 2
BOW FLAP WITH DEADRISE AND GAP, WHEEL COVERS ON

# DAT
# FILM